Radio, Electronics and Communications

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In This Issue . . .

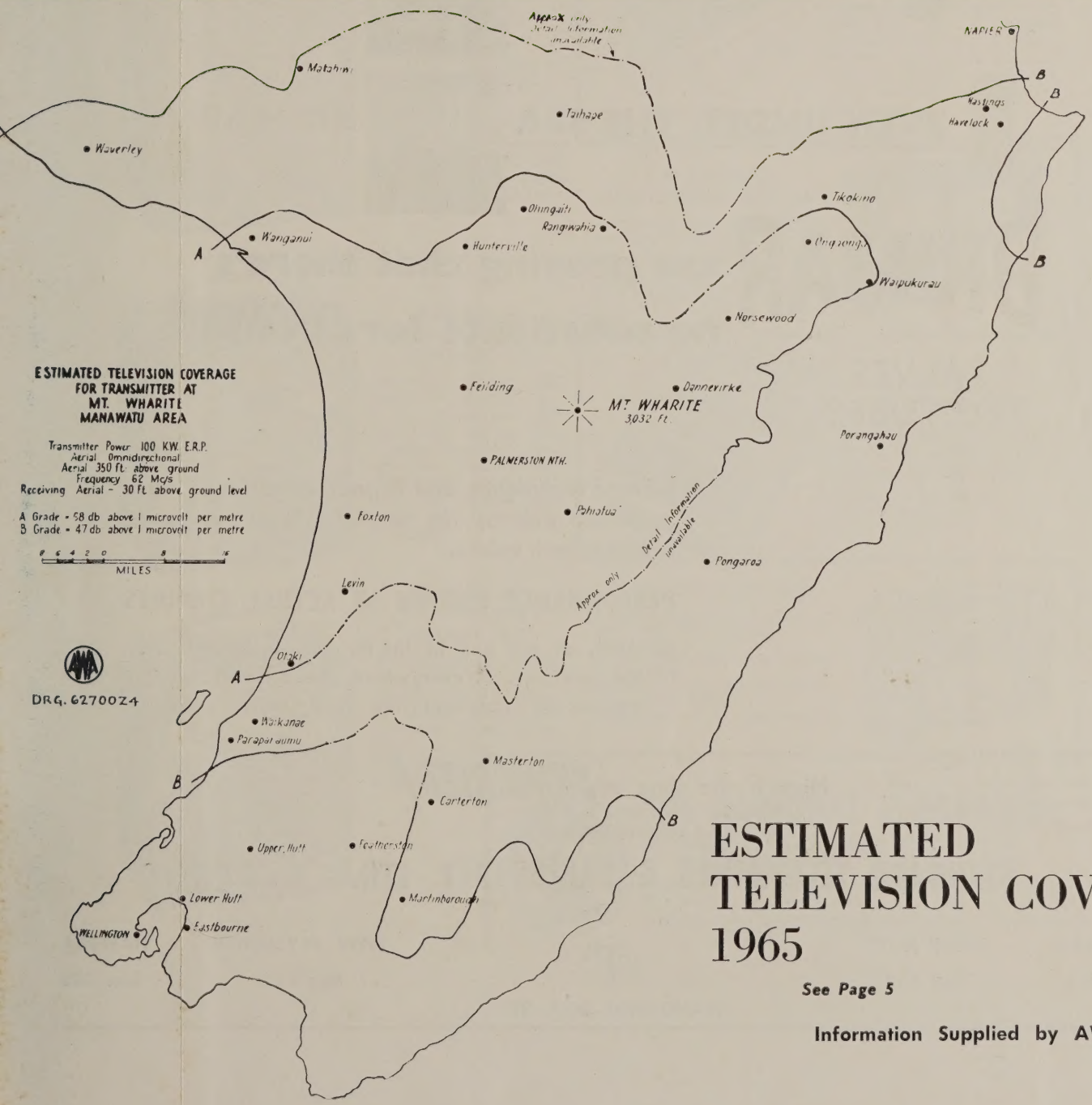
- Looking at Varactor Diodes
- Transistorised Low Voltage Power Supply
- Audio Frequency Meter
- N.Z.B.C. Report—concluded
- Radio-Wave Propagation—Part IV
- Serviceman's Column; General Features

PUBLISHED MONTHLY IN THE INTERESTS OF THE N.Z. ELECTRONICS INDUSTRY FOR ALL LEVELS, FROM PROFESSIONAL TO AMATEUR.

VOLUME 19 NUMBER 3

MAY 1, 1964

PRICE 2/6



ESTIMATED TELEVISION COVERAGE 1965

See Page 5

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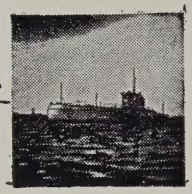
EVEN UNDER THE SEA  BRIMAR

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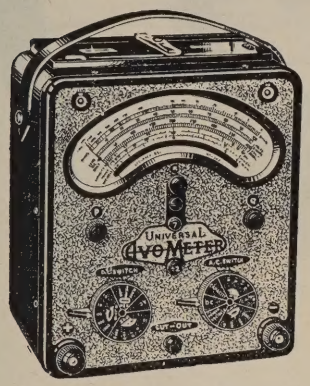

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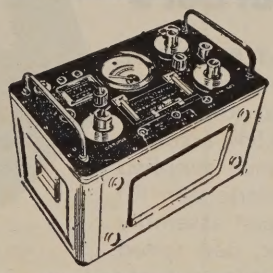

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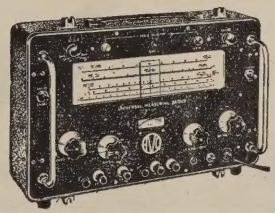

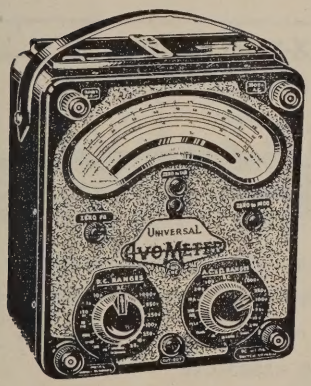

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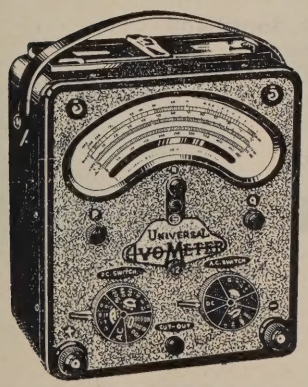

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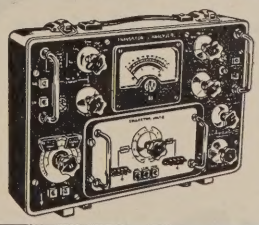

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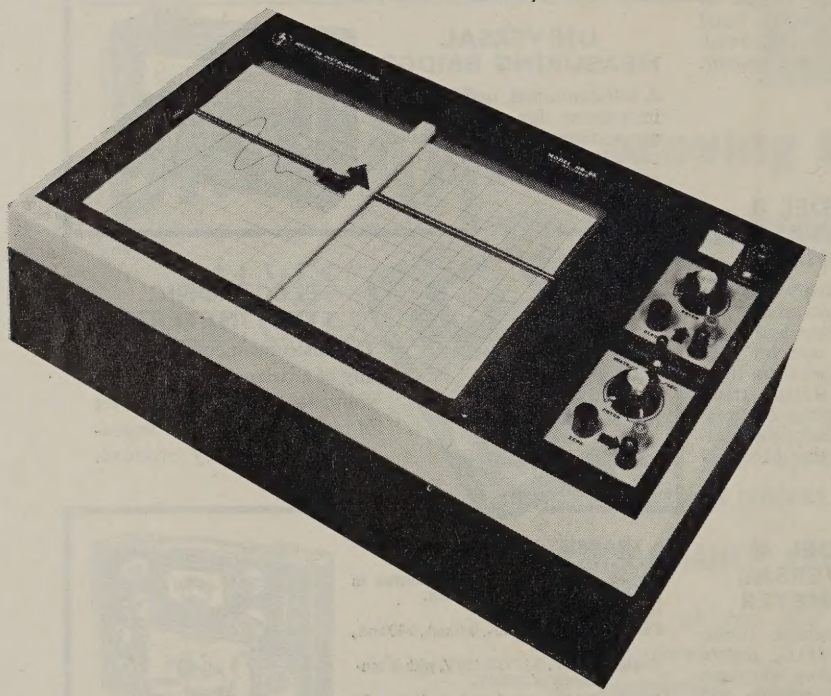

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Dear Sir,

In the February issue of your magazine, in the Shortwave Notes, you mention a World Shortwave Radio Map and Handbook.

Could you please tell me where I can obtain this or where I can obtain information about this item.

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I hope someone will continue the shortwave notes.

Yours sincerely,
RONALD LANCE JAMES

The World Shortwave Radio Map and Handbook is available from stock from the Publications Dept., The Short Wave Magazine, 55 Victoria St., London, S.W.1. This was mentioned in the article to which you refer, at the conclusion of the second-to-last paragraph.

—The Editor.

Readers are referred to the Editorial on page 7 and the announcement made there. In pursuance of our aim of moving with the times we look forward to receiving readers' comments, suggestions and criticisms—both over particular topics and general broad fields.

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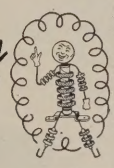

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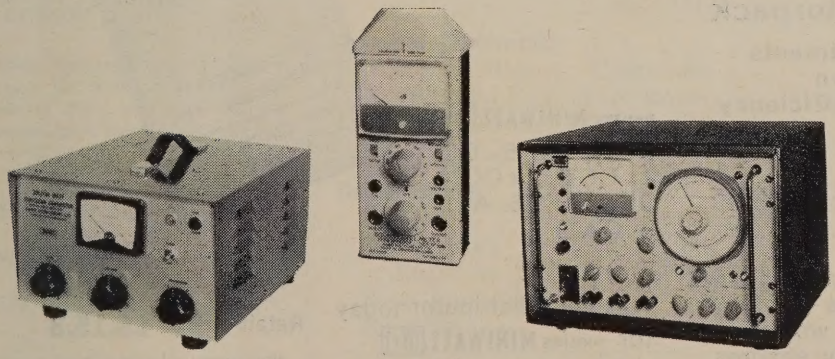

Left: Soniclean Generator.
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Right: Audio Sweep Oscillator

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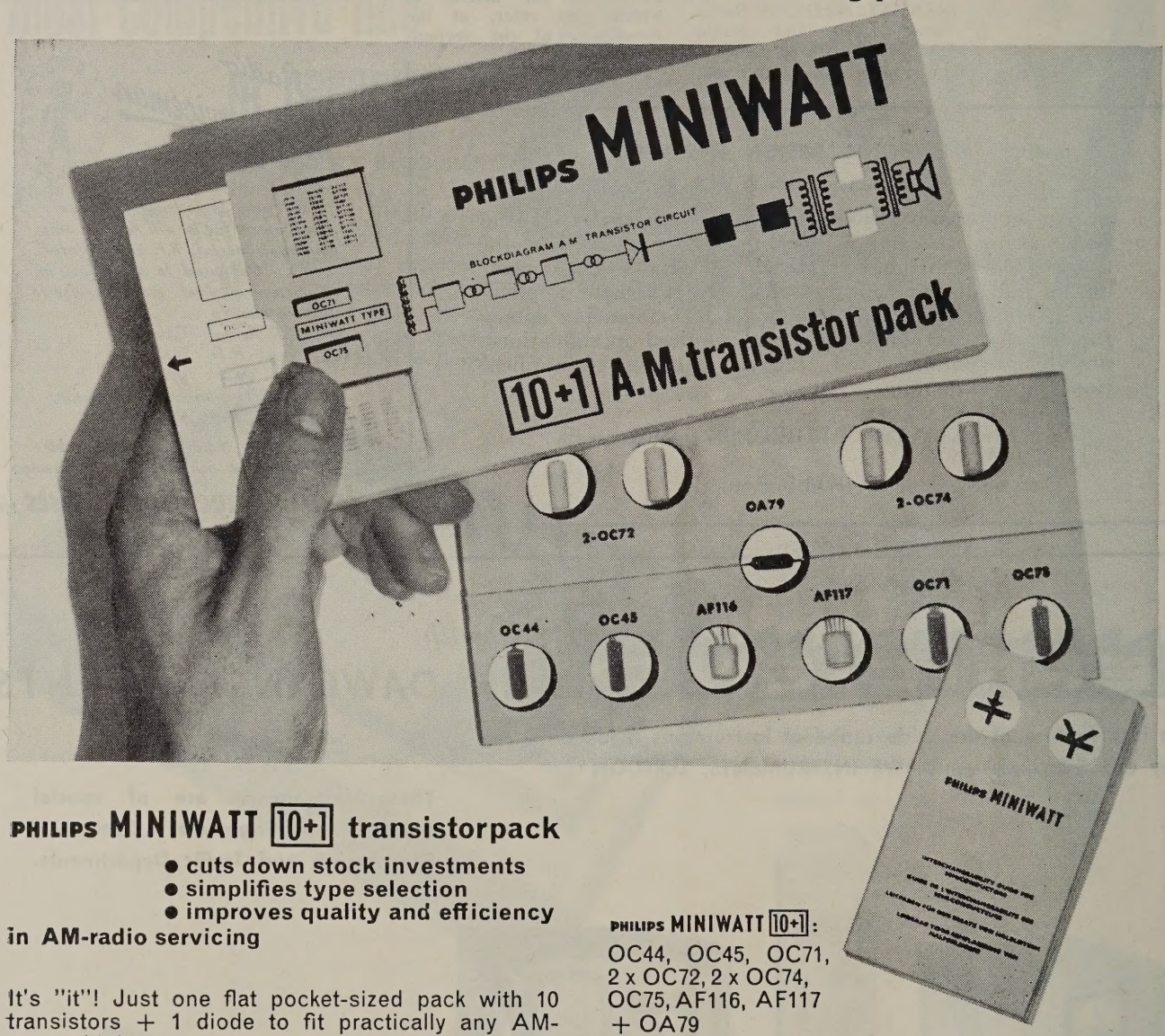

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On Our Cover

When the 100kW Television Transmitting Stations at Auckland, Te Aroha, Wharite and Christchurch are commissioned during 1965, Phase 1 of the New Zealand Broadcasting Corporation's Television Coverage Programme will have been completed and the majority of our population will be able to receive a good television picture.

The cover picture shows the estimated television coverage for a 100kW transmitter situated at Wharite in the Manawatu and other estimated coverage diagrams are illustrated in the text of an article "Planning a Television Transmitting Station" which will appear in the June issue.

Some of the questions which will be considered in the article are:—

What signal strength is required and over what area?

What effective Radiated Power is required?

What is the height of the transmitting site necessary to give adequate coverage?

What type of aerial supporting structure should be used and how high should it be?

What type of aerial should be employed and should it be "special?"

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FEATURED NEXT MONTH . . .
Looking at Methods of Audio Measurement.
A Low Distortion Audio Oscillator.
Electrostatically Focused Cathode Ray Tube.
Planning a Television Transmission Station.
Some Aspects of V.H.F. Mobile Operation.
Laboratory Report.

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New Products
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"R&E" *goes marching on . . .*

1946 — Radio and Electronics

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—— "R & E" moves with the changing times.

The new title, Radio, Electronics and Communications, is intended both to retain contact with readers who have known the magazine for many years and also to reflect the rapid development in the vast field of electronics. Within the half-generation since the first issue of R & E, in 1946, the progress of electronics has been so tremendous that probably few minds can yet comprehend its implications, its many and inevitable effects on our life. This progress has been such that a journal endeavouring to keep abreast of the industry must itself change. In this field, possibly more than any other, it is vitally important that publications themselves develop abreast of these changes in the science itself if they are to fulfil their role.

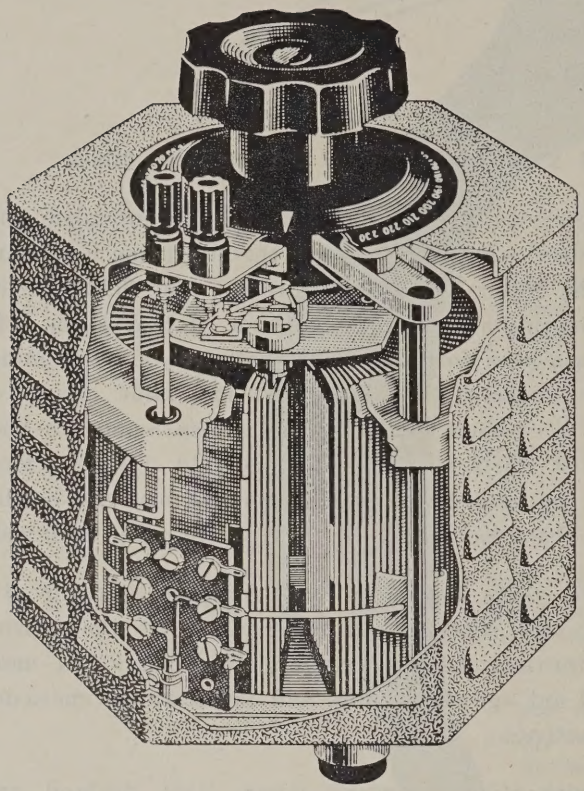
The past two or three years have witnessed positive steps by the editors to reshape the editorial content and to ensure that the journal remains in harmony with the everchanging scene. This change in name is a step which we feel will aid our endeavours and facilitate an unceasing review of the magazine's content.

We take this opportunity of greeting our many New Zealand and Overseas readers who have been with us for a long time, and also our staunch group of advertisers.

Our title page this month carries a new device intended to mark the qualities which readers are entitled to look for in our publications. It symbolizes what we believe to be the proper aims of conscientious publishing. The sword stands for courage—or strength in support of the public good. The mighty pen stands for truth—the obligation laid upon all who assume the privilege of the printing press. The brush represents art—and with it beauty. The cog-wheel indicates that publishing consists of processing these principles, by mechanical and industrial means, into a physical form suitable for mass distribution.

Courage, truth and art are the beacons which should light a publisher's way, the principles which must inform his pages.

PHILIPS *Variable transformers*



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LOOKING AT

HIGH-POWER VARACTOR DIODES THEORY AND APPLICATION

By Gerald Schaffner *

The demand for solid-state equipment with continually increasing power output at higher frequencies is rapidly accentuating interest in varactor diodes as frequency multipliers. This article treats varactors in non-rigorous terms, discussing what they are, how they work, and how to use them in practical high-power, high-frequency output circuits.

Conventionally speaking, when we refer to a semiconductor diode we normally visualise a 2-terminal p-n junction operated in the forward conduction region (as a rectifier) or in the reverse avalanche region (as a zener diode). From this standpoint, the word diode applied to a varactor is actually a misnomer—for while the varactor is indeed a 2-terminal p-n junction, it operates neither as a rectifier, nor as an avalanche device. Rather, it operates principally in the region between forward conduction and reverse breakdown—the very region in which a conventional diode is considered to be cut off.

In this operating region the p-n junction can be represented by a capacitor in series with a resistor, Fig. 1. The capacitance, known as junction capacitance, is inherently associated with all p-n junctions and, while it represents an undesirable parasitic in conventional diode operation, it is the specific mechanism that permits the device to function as a

Figure 1 — Equivalent circuit of a varactor diode.

varactor, or frequency multiplier. This is true because the capacitance value, as will be seen later, actually varies as a function of applied voltage and it is this factor that encourages the generation of harmonic frequencies.

The resistor is the result of bulk and contact resistance of the semiconductor material. In varactor operation this resistance is the primary parasitic affecting varactor quality. Great pains are taken in varactor design, therefore, to hold this resistance value to an absolute minimum.

How They Work

The cause and behaviour of the junction capacitance can be determined from basic semiconductor theory, as follows:

* Senior Engineer, Motorola Inc., Phoenix, Arizona.

VARACTORS vs. TRANSISTORS

In view of the fact that varactors provide no amplification, but merely convert an applied signal of one frequency to some higher frequency, one might logically ask: "Why not use transistors to directly generate the desired signal?" The answer to this is simply that there are no transistors that will provide the amount of power obtainable from varactors in the VHF and UHF regions. The best transistors today are limited to producing about 25 watts at 100 mc, and about 5 watts at 500 mc. Varactors, by contrast, can supply about three times that amount of power at those frequencies. Moreover, many VHF and UHF transmitters demand crystal control, which requires a relatively low-frequency oscillator with subsequent frequency multiplication. And, as yet, no other device operates as effectively as a varactor for this purpose.

Even as transistors are improved, it is reasonable to assume that varactor development will keep pace, so that the latter will remain well ahead of transistors in power-frequency capabilities. As a result, it is anticipated that the varactor will become an increasingly important component in high-power, high-frequency applications.

When a junction is formed between n-type and p-type material, there is a cross-migration of charges across the junction. Electrons from the n-region cross the junction to neutralise positive carriers near the junction in the p-region, and "holes" from the p-region cross the junction to neutralise the "excess" electrons near the junction in the n-region. As a result of this migration, all free charged particles are swept out of the immediate vicinity of the junction, creating a "depletion layer" in the junction area. And, in the process, a contact potential or space charge (about 0.5V for silicon) appears across the junction, Fig. 2a.

This structure acts very much like a slightly charged capacitor, with the depletion layer representing the dielectric and the semiconductor material adjacent to the depletion layer representing the two conductive plates.

If an external voltage is connected across the

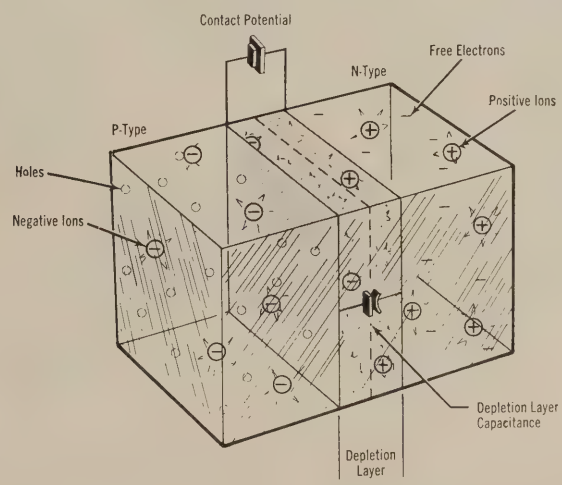


Figure 2 — (A) A representative p-n junction. The battery represents the contact potential which must be overcome before current can flow. Current carriers act as capacitor plates and the depletion layer is the dielectric.

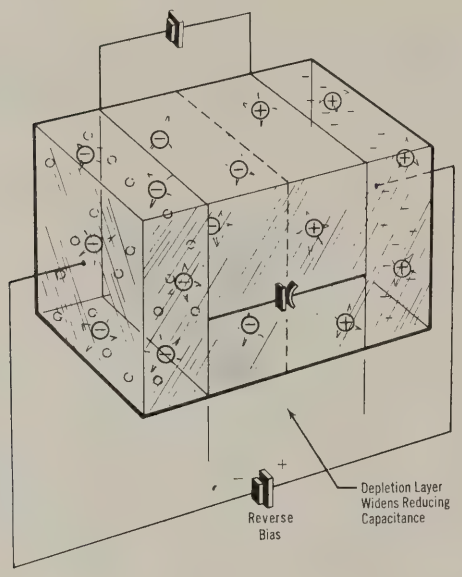


Figure 2 — (B) Reverse voltage forces carriers away from junction. This widens the depletion layer and reduces capacitance.

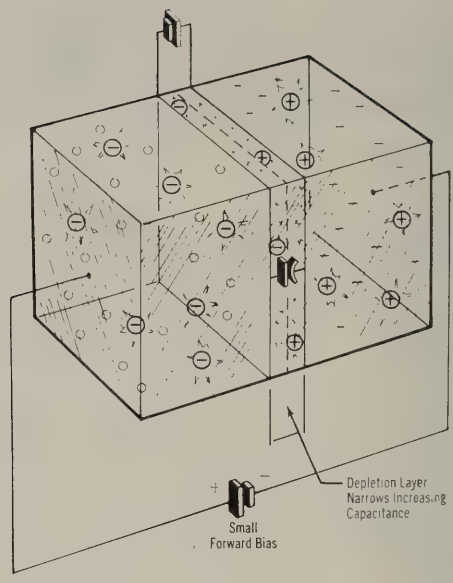
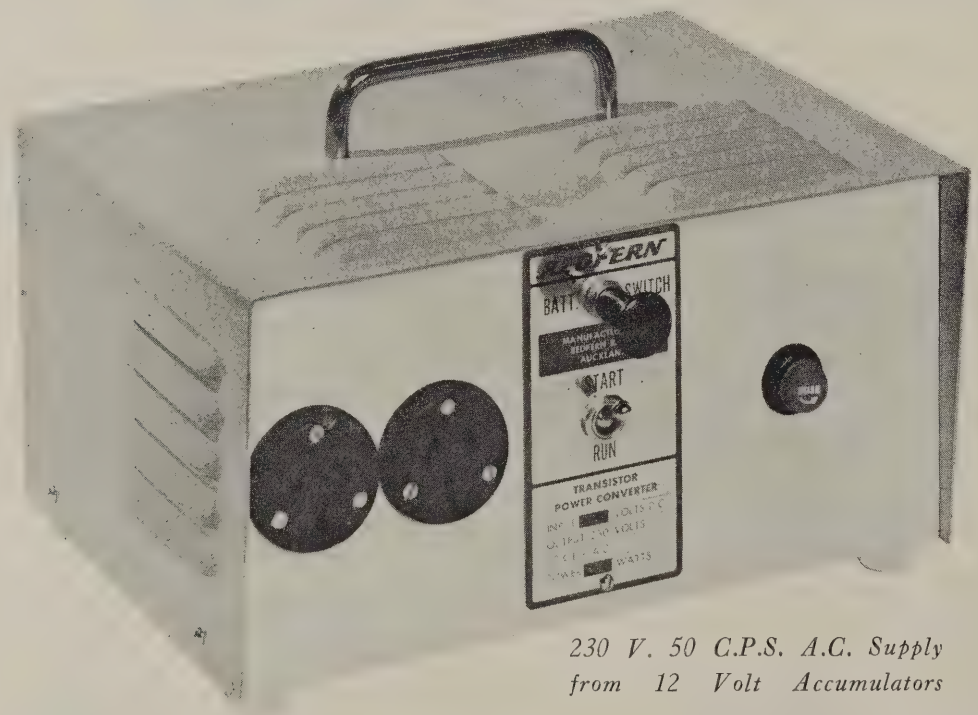


Figure 2 — (C) Forward voltage forces carriers closer to junction or across junction again changing capacitance.

p-n junction so as to reinforce the contact potential (reverse bias), the depletion layer increases, resulting in a capacitance decrease, Fig. 2b. If a forward voltage is applied, the depletion layer decreases, Fig 2c. However, if the external forward voltage is made large enough to overcome the contact potential, forward conduction occurs and the capacitance is destroyed (except at very high frequencies, as discussed later).

It is obvious, therefore, that the value of the junction capacitance is a function of the externally applied voltage, so long as the junction itself remains reverse biased. This relationship is as follows:



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$$C = Co/(1 + V/\phi)^1 = \phi^1\ Co/(\phi + V)^1$$

where C = capacitance at voltage V
Co = capacitance at zero bias
V = voltage across the diode (reverse bias)
ϕ = contact potential
1 = power law of the junction, determined by impurity gradient.

A plot of this equation, figure 3, shows that the capacitance-voltage relationship is non-linear. Just how this condition is useful for frequency multiplication will be seen from the following derivation.

Assume that the voltage across a capacitor is given by the well-known relationship.

$$V = Q/C \qquad (2)$$

where Q = the charge on the capacitor
C = the capacitance

When a sinusoidal current is applied to a capacitance,

$$Q = \int idt = \int I_1 \sin \omega_1 t\, dt = A - \frac{I_1}{\omega_1} \cos \omega_1 t \qquad (3)$$

where i = instantaneous current
I_1 = maximum amplitude of the input current
$\omega_1 = 2\pi f_1$
f_1 = input frequency
A = constant of integration relating to the initial charge when time (t) = zero

Substituting Equations (1) and (3) into Equation (2) yields

$$V = \frac{A - (I_1/\omega_1) \cos \omega_1 t}{\phi^1\ Co/(\phi + V)^1} \qquad (4)$$

or, where V is greater than ϕ

$$V = V^{1-1} = \frac{A - (I_1/\omega_1) \cos \omega_1 t}{V^1} \qquad (5)$$

$$\frac{}{\phi^1\ Co}$$

The exponent 1 is a function of the impurity gradient of the p-n junction. It may vary from approximately 1/2, for step junctions, to about 1/6 for special graded junctions. If we consider the common case of a step junction, (1 = 1/2) Equation (5) resolves to

$$V = \left(\frac{A - (I_1/\omega_1) \cos \omega_1 t)}{\phi^{1/2}\ Co}\right)^2 = \frac{A^2\text{-}2A\ (I_1/\omega)\ \cos \omega_1 t + (I_1/\omega_1)^2\ \cos^2 \omega_1 t}{\phi\ Co^2} \qquad (6)$$

Looking at each of the terms in Equation (6) we find that the voltage (V) across the varactor consists of a dc term ($A^2/\phi\ Co^2$), a fundamental Component $\left(\frac{2A\ (I/\omega_1)\ \cos\ \omega_1 t}{\phi\ Co^2}\right)$ and the term $\frac{(I_1\omega_1)^2\ \cos^2 \omega_1 t}{\phi\ Co^2}$

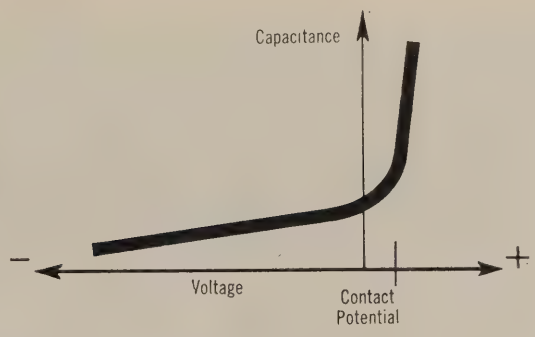

Figure 3 — Voltage-capacitance relationship for a typical varactor diode.

The latter, through trigonometric identities, $(\frac{1}{2} + \frac{1}{2} \cos 2\omega_1 t)$ expands to $(I_1/\omega_1)^2$ ———————, which reduces to another dc component plus a second harmonic component.

$\phi\ Co^2$

Although quite simplified, the above derivations clearly show the generation of second harmonic voltages across the varactor diode. This second harmonic voltage can be used to produce power at that frequency simply by providing a path and a load for the second harmonic current.

In the case of a step-junction device, the second harmonic is the only harmonic frequency directly available. While it is possible, through the use of graded junctions (1 less than 1/2) to obtain higher harmonics directly, the second harmonic always predominates. In fact, it is normally more efficient to obtain higher harmonics by means of the doubling and mixing action of the varactor, through the use of idler circuits (see Fig. 4), than to try to obtain a desired higher harmonic directly.

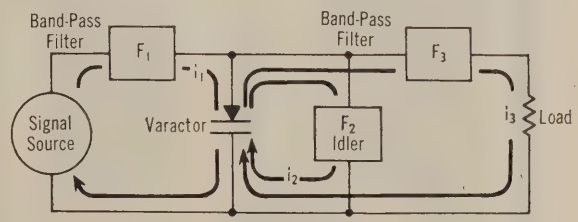

Figure 4 — Simplified multiplier circuit illustrating the use of an idler configuration to develop third and fourth harmonics.
An idler circuit is simply a tuned filter which permits the flow of a harmonic current needed to generate the desired output. If the third harmonic is desired, filter F_1 is tuned to the fundamental, idler F_2 is tuned to the 2nd harmonic, and F_3 is tuned to the 3rd harmonic. To obtain the fourth harmonic, F_3 is simply tuned to the fourth harmonic and permits the flow of the doubled 2nd harmonic current.

Varactor Characteristics

When operating as a frequency multiplier, the important varactor characteristics are: efficiency as a multiplier, power handling capability, and, in some applications, linearity of power output with changes in input power.

Continued on page 35

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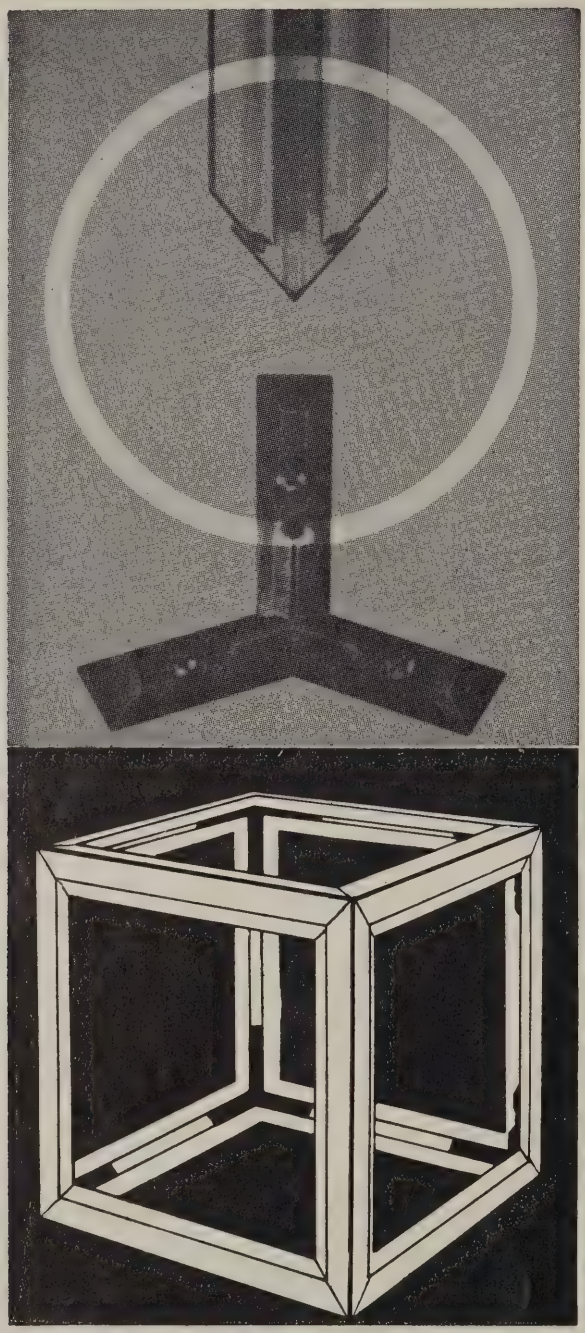

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A Direct Reading Valve Type Audio Frequency Meter

"Radio and Electrical Review" for May 1961, published an article by R. J. Hall entitled "Transistor Frequency Meter" describing a direct reading meter of range 0—100 Kc/s. Being a transistorised unit the only disadvantage is that the input voltage had to be switched so as to protect the first transistor against too high a voltage. The unit described below is valve operated and any input up to 250 volts can be safely applied to the input terminals. Its other advantage is that constructors familiar with valve circuits but unfamiliar with transistors will be "at home." Reference to the circuit shows that one stage is stabilised—there is little reason why the driver stage should not also be stabilised to obtain better accuracy than the ± 3% afforded by the existing circuit.

The circuit is straight forward and was, in fact, first built up from an audio amplifier output and driver section. When a voltage applied to a capacitor can be made independent of frequency the average current flowing into it is proportional to the rate of charges per second and hence to the frequency. The circuit consists of two stages, V1 and V2, charging a capacitor Cc. which is discharged through V3. In the first stage the input signal is amplified (if it is of low value) or clipped (if it is of high value). This amplified and partially clipped signal is fed into V2 which is very much overdriven to result in a square wave output which will be of constant amplitude despite input voltage level variations and will vary only in rate, i.e. frequency. This square wave is then differentiated through Cc. and becomes a series of spiked pulses.

The pulses are applied to a double diode, V3, connected back to back. So connected the capacitor charging current passes through one diode whilst the discharge current flows through the other. In this way the charging current can be shown on a meter in the diode circuit. The D.C. is proportional to the number of times the capacitor is charged per second (i.e. to the frequency). The D.C. flowing is also proportional to the charging voltage but the regulated supply on V2 ensures that a constant potential is applied.

The full scale deflection of the meter is dependent upon the meter sensitivity and the value of the charging capacitors.

The Circuit

The circuitry associated with V1, V2, V4 and V5 require no comment.

The value of capacitors Cc. were chosen to suit a milliameter on hand, but it is suggested that these values be kept to.

To allow for slight irregularities in overlap and accuracy of the charging capacitors each range has its own adjusting potentiometer as a meter shunt. The final value of these shunts will depend upon the milliameter selected but 500 ohm potentiometers have been selected as the best choice to pair up with the usual meters available. For reasonable accuracy in reading a 4in. scale length meter should be employed.

The meter chosen will in some manner reflect upon range division as it is easier to calibrate or mark a scale in multiples or sub-multiples of 100, such as $\frac{1}{2}$ or $\frac{1}{4}$ than in 1/3, thus 0—100, 0—250, 0—1000 cycles will be the most convenient scale.

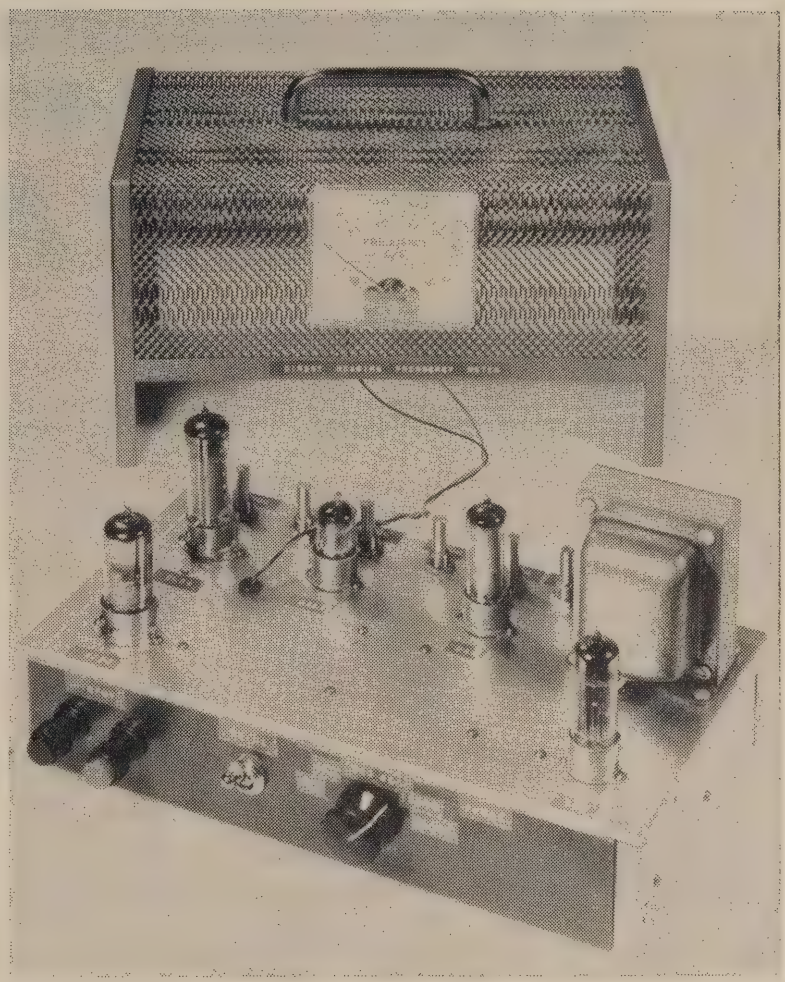
The instrument described has its top range 0—100 Kc/s., but it is thought that the top range could be extended. However, as other methods of frequency measurement are available at radio frequencies no attempt has been made to measure higher than 100 Kc/s.

Calibration should be done against known frequencies, but they need not be sine waves—a C.R.O. time base saw tooth gives comparable calibration results.

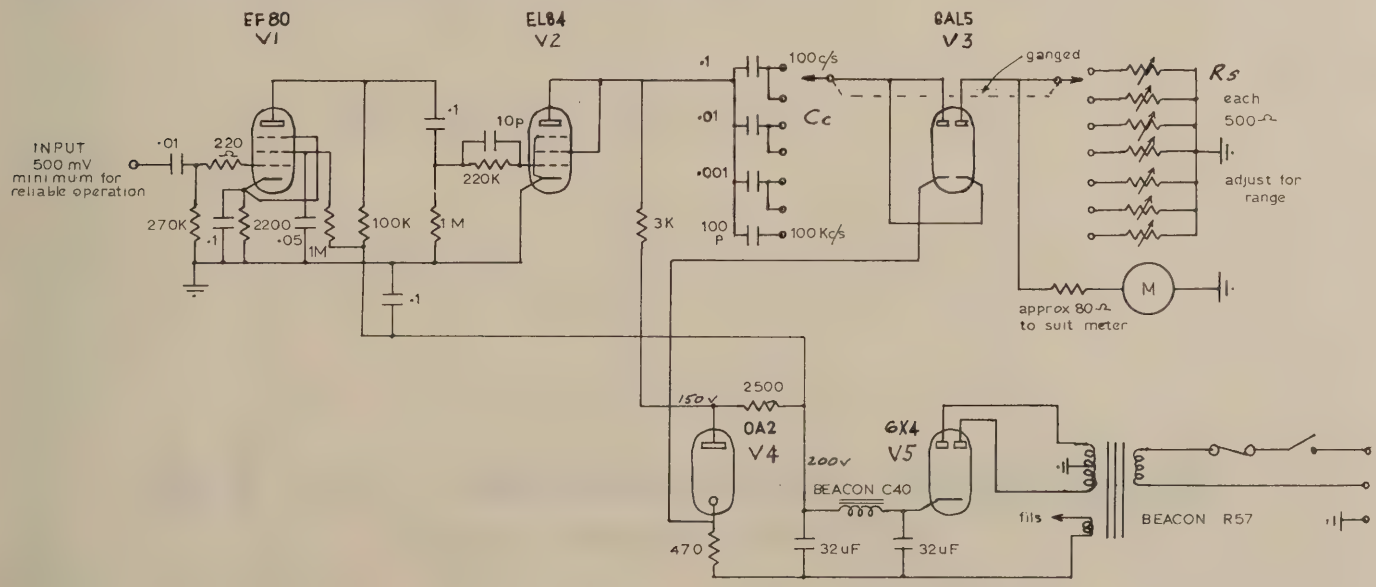
After warm up the overall accuracy using a ± $1\frac{1}{2}$% meter, was better than ± 3%. There is no reason why close tolerance charging capacitors and further stabilisation could not result in an accuracy of better than ± 2% and should a precision meter be used ± 1% could be obtained.

The instrument has now been used over some time for the rapid measurement of a variety of audio signals and is superior to frequency measurement by means of a service type C.R.O. on account of the time saved. Ability to measure up to 100 Kc/s. has meant the rapid adjustment of tape recorder bias frequencies and audio oscillators. Both hands can be used for adjustment instead of one hand being used to "sweep" the C.R.O. time base control.

Whilst "modern" type valves are shown in the circuit almost any amplifier pentode can be used for V1, and any power pentode for V2. For V3 a 6H6 would be an ideal substitute. The omission of



the regulator valve, V4, has not been investigated but the shortage of a regulator valve should not prevent construction but circuit valves would have to be chosen to ensure that about 150 volts appears on the B+ side of the 3.3K resistor of V2. The omission of V4 would necessarily mean a lessening in accuracy.



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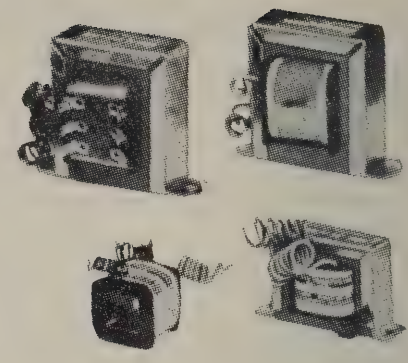

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†OP2	3	7K/3 ,,	9/16 ,,	Yellow	,,
†OP3	3	10K/3 ,,	9/16 ,,	White	,,
†OP3 C	3	10KCT/3 ohms	9/16 ,,	White	,,
†OP4	6	5K/3 ,,	¾ Square	Red	,,
†OP5	6	7K/3 ,,	¾ ,,	Yellow	,,
†OP6	6	10KCT/3 ,,	¾ ,,	White	,,
†OP7	6	14KCT/3 ,,	¾ ,,	Black	,,
†OP8	4.5	5K/3 ,,	11/16 x 13/16	Red	,,
†OP9	4.5	7K/3 ,,	11/16 x 13/16	Yellow	,,
†OP10	4.5	10KCT/3 ,,	11/16 x 13/16	White	,,
†OP11	4.5	14KCT/3 ,,	11/16 x 13/16	Black	,,
†OP12	4.5	Universal	11/16 x 13/16	—	,,
†OP13	6	Universal	¾ x ¾	—	,,
†OP14	10W	Universal	⅞ x ⅞	—	,,
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OP16	20	6.6KCT/ ,,	1" x 1¼	—	,,
OP17	20	10KCT/ ,,	1" x 1¼	—	,,
OP21	2W	5K/3	½"	Red	Windings Only
OP22	2W	7K/3	½"	Yellow	,, ,,
OP23	35W	5KCT/Univ.	2" x 1¼	—	Covers & Feet
OP24	35	6.6KCT/ ,,	2" x 1¼	—	,, ,,
OP25	35	10KCT/ ,,	2" x 1¼	—	,, ,,
OP26	15W	Hifi 5KCT/15 ohms	2" x 1¼	—	,, ,,
OP27	15W	Hifi 8KCT/15 ,,	2" x 1¼	—	,, ,,
OP28	15W	Hifi 10KCT/15 ,,	2" x 1¼	—	,, ,,
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OP29	20W	6.6KCT/15 ohms	2" x 1¼	—	,, ,,
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OP33	6W	8KCT/15 ,,	1¼" x ⅞"	—	Clamp
OP34	3W	Universal	9/16 x 9/16	—	,,
OP35	6W	10KCT/15-7.5-3 ohms	¾ x ¾	—	,,
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Radio-Wave Propagation and the Planning of V.H.F. & U.H.F. Sound and Television Services

by G. A. Vickers, B.Sc., A.M.I.E.E., A.C.G.J. *

PART 4

Co-Channel Interference

If an unacceptable level of co-channel interference is to be avoided, the strength of the unwanted signal (or the effective strength of two or more such signals) must be very much less at the receiver input than that of the wanted signal. Since the majority of co-channel signals result from sporadic tropospheric propagation (reflections, super-refraction or ducting) or, at the low v.h.f. frequencies, from sporadic ionospheric reflections, their strengths fluctuate widely, and to provide a wanted signal which is at all times strong enough to over-ride the unwanted signal throughout the whole of a service area is seldom a practical proposition. It is necessary, therefore, to decide at the outset what is the lowest field strength of the wanted signal to be protected against co-channel interference, and for what percentage of the time. It should be mentioned that the occurrence of co-channel signals will tend to be concentrated within relatively long periods of up to several days or, in some parts of the world, even weeks while the causative meteorological or ionospheric conditions persist. The time percentage must, therefore, be thought of as a percentage of a year or even more.

In estimating the probable level of co-channel interference caused within the service area of one station by the signal from another, it is first necessary to determine the likely strength of the unwanted signal at selected receiving localities. Since time seldom permits long-term recordings to be made, empirical curves, such as those prepared by C.C.I.R. are almost invariably used for tropospheric signals; except perhaps in the case of an important town for which the curves forecast an unacceptable degree of interference from an existing station and where, by means of a recording it is hoped to prove the curves to be pessimistic over the particular path in question ([6]). Statistical data is also available for forecasting ionospheric signals.

A good guide to the degree of tropospheric interference likely to be experienced in the service area as a whole can usually be obtained by forecasting the strength of the unwanted signal in the towns which are nearest and farthest from the distant station and in which the wanted signal is known or predicted to be the lowest value to be protected. In the nearest town, the unwanted signal will probably be at its strongest, but the receiving aerials, assumed of high gain, will be directed in the opposite direction and will, therefore, discriminate to some degree against the unwanted signal. In the remote town, the tropospheric signal will be weaker owing to the increased distance, but the receiving aerials will now be pointing in the general direction of the distant station and will no longer be able to discriminate.

Freedom from ground wave interference, however, should not be taken for granted, especially as the relative stability of this wave could result in continuous and, therefore, much more serious interference than the sporadic signals via the troposphere or ionosphere. The strength of the ground wave can be obtained by prediction from the path profiles.

From the empirical curves a very approximate value of field strength, which, for 1kW e.r.p., is likely to be exceeded in 50% of the receiving locations during 1, 10 and 50% of the time, can be estimated. For normal purposes, interference-free reception is generally sought for 99% of the time and, therefore, the 1% curves are used.

Recommended minimum acceptable protection ratios at the input of the receiver are quoted by C.C.I.R. for both v.h.f. f.m. sound broadcasting and the various television systems. The figure for television, in cases where the co-channel stations have the same line frequency and carrier frequencies separated by less than 1,000 c/s but not synchronised, is 45 dB, which is equivalent to a voltage ratio of 180/1.

It does not follow, however, that a protection ratio as high as this has to be achieved between the two field strengths at the receiving aerial. It is often possible to accept a considerably lower field strength ratio by discriminating against the unwanted signal in one or both of the following ways.

(1) Aerial Discrimination

Discrimination can be provided by the receiving aerial either by arranging (if allocations permit) for the polarisation of the radiation from a proposed station to be vertical if the distant station is horizontal (or vice versa), or by using a high gain receiving aerial which will discriminate to the extent of the difference in gain between the directions of the wanted and unwanted stations.

In the case of cross-polarisation, additional protection of approximately 10 dB can be claimed depending on frequency and on the design and environment of the aerial, while for aerial directivity, typical values in directions well removed from the main lobe range from 6 dB in the lower v.h.f. band to 16 dB in the u.h.f. band. These values can also be influenced adversely by the environment of the aerial. There will, of course, always be an area within which the receiving aerials will be pointing towards or in the general direction of the unwanted station, in which case no discrimination would be obtained for aerial directivity. If cross-polarisation exists between the two stations, the receiving aerial

(* The Marconi Company Limited, Chelmsford, England)

will, in theory, have no directional properties in the horizontal plane so far as the unwanted signal is concerned. In practice, departure from ideal conditions may result in a small degree of discrimination over and above that resulting from the use of cross-polarisation.

With only vertical and horizontal to choose from, the use of cross-polarisation is obviously restricted where more than one pair of stations is involved.

An important distinction must be made between tropospheric and ionospheric signals. In the former, the wave polarisation is preserved in the received signal while, in the latter, it tends to be random. The use of cross-polarisation cannot, therefore, be counted upon to discriminate against ionospheric co-channel interference.

(2) Frequency Discrimination

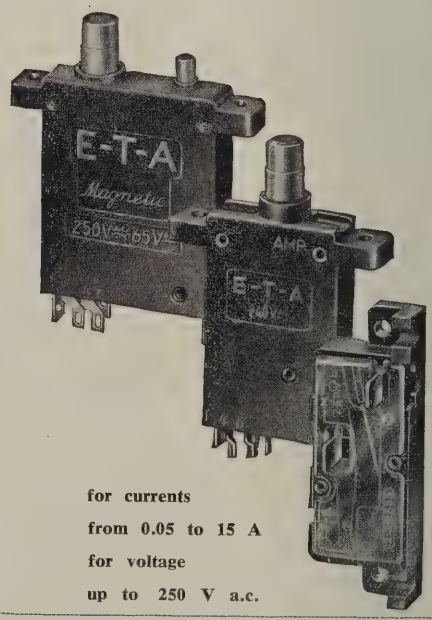
By arranging for the carrier frequencies of two television stations operating on the same channel to be separated by a few kc/s, the visibility of the co-channel interference bars on the television screen resulting from an inadequate wanted or unwanted signal ratio at the receiver input can be considerably reduced.

This added protection reaches its maximum of approximately 20 dB when the offset is equal to an odd multiple of half the line frequency but, although this offset could be applied satisfactorily to an isolated pair of co-channel stations, the introduction of a third station would inevitably lead to an even multiple offset between one pair of stations and negligible benefit would be obtained. To overcome this limitation, the more flexible offsets of one-third, two-thirds, four-thirds or five-thirds of the line frequency are generally used, although at a sacrifice of approximately 5 dB, in protection.

The foregoing can be applied to the majority of present-day television transmitters whose carrier frequencies are controlled to within ± 5,000 c/s of the nominal value. Additional protection of the order of 10 dB can be obtained if "precision" offsetting is used. The offsetting frequency, while still approximating to one of the above fractions of the line frequency, is held to an even multiple of the field, or frame, frequency. Since the latter requirement demands that the carrier of each station must be stabilised to within a few cycles per second and that the scanning frequencies must be kept constant to within a few parts in 10^5, the provision of precision offsetting presents many problems.

When both cross-polarisation and normal carrier offsetting are employed, the minimum acceptable protection ratio of wanted to unwanted field strength at the receiving aerial of a television receiver can be reduced by approximately 25 dB, or 35 dB if the studio and transmitting equipment at each station were capable of precision offsetting.

Should the investigation of co-channel signals reveal the possibility of excessive interference within the service area of an existing station, steps have to be taken in the planning to ensure that such interference will not occur when the proposed station becomes operative.



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It is unlikely that the overall co-channel problem in any particular region of the world will enable the allocated channel to be changed or cross-polarisation and carrier offset to be adopted if not already allocated. The simple solution, subject to being technically possible, is to amend the shape of the azimuthal polar diagram of the transmitting aerial so that the power radiated towards the service area of the distant station is reduced sufficiently to prevent unacceptable interference. If the result of having to do this is a serious reduction in the local service area, it is possible that an alternative transmitting site might, by changing the bearings of the town to be served and of the distant service area, prove to be the best compromise solution.

If, on the other hand, the existing station is likely to cause interference within the service area of the proposed station, consideration should be given to the possibility of increasing the e.r.p. of the proposed station towards the areas within which interference is expected. It may well be, however, that the necessary increase in power will either introduce or aggravate interference to the distant station and, again, a better solution may lie in a change of site.

Planning

An outline has now been given of the more important features of radiowave propagation in the v.h.f. and u.h.f. broadcast bands, together with an account of their influence on the wanted and the unwanted signals within a broadcast coverage. Also, the methods by which field strengths can be forecast have been reviewed and special attention has been devoted to the method of prediction based on theoretical calculations as used by the Marconi Company. It now remains to describe the application of this latter method of prediction to the planning of a broadcast service, particularly with reference to stations required to provide more than a mere local coverage, and to discuss some of the planning problems which may be encountered.

Once the total area to be served has been decided, the broad sequence of events will, in general, be along the lines already mentioned at the beginning of this article, namely the estimation of the number of stations needed and their approximate siting and radiated powers, the allocation of channels, the determination of the final sites and station characteristics, and the estimation of the service areas and, perhaps, the number of potential listeners or viewers, having taken into account possible co-channel interference and fading.

(1) Number of Stations

An experienced radio-wave propagation engineer is able to decide, after a study of contoured maps or, better still initially, a relief map, if and how the desired area must be divided into two or more separate coverages, and which are the more promising transmitting sites worthy of detailed investigation. Although local knowledge of topographical details may, in some cases, prove useful, it is very unlikely, except perhaps for small service areas, to render contoured maps unnecessary.

(2) Channel Allocations

At this stage, the allocation of frequency channels, as well as polarisation and carrier frequency offsetting, should be decided, either by application to the relevant allocation authority or, where appropriate, by local agreement.

The choice of television band — if a choice exists —depends to some extent on the particular circumstances but, in general, perference would be given, for reasons already mentioned, to the lowest frequency band within which there is available space, especially when the desired service area is large and, even more important, if the terrain is hilly. If, however, the lower v.h.f. band is selected, the higher frequency channels should, where possible, be used in preference to channels below approximately 60 Mc/s in view of likely long-distance ionospheric interference in the lower channels.

Allocations should take into account any proposed future extensions or new services in the same band. An ill-considered allocation to even a single station in the first phase of a comprehensive scheme may be regretted later when it is found to impose a restriction in the allocations to subsequent stations.

In addition to the overriding need to confine co-channel interference to within acceptable limits, two other considerations may influence the selection of channel for each station.

First, if the public is likely to be offered the choice of two or more services, the relationship between the channels and the i.f. and local oscillator frequencies of the receivers should be investigated in order to avoid the danger of the radiation from a receiver tuned to one service causing interference in a nearby receiver tuned to another service.

Secondly, if the hope is to be able to link one station to another by means of direct "off the air" pick-up, steps should be taken to ensure that at least one guard channel exists between each pair of stations to be so linked.

(3) Choice of Transmitting Site

It will already be clear that the most efficient site is a hill top which is sufficiently elevated above the surrounding terrain to minimize attenuation of the signal to all important receiving localities. Height, therefore, is nearly always of utmost importance, whether to enable the aerial to "see" over hills or minimize the extent to which, in smooth terrain, the ground reflection opposes the direct wave.

It cannot be stressed too often that the choice of site and of the height of the aerial above the site, and surrounding area can have a profound influence on the resulting coverage and on the radiated power required to give this coverage. An increase in aerial height at a given site may enable a particular town or group of towns to be served where before no practicable value of radiated power would be sufficient. In this way, it may be possible to reduce the number of stations (and channels) required. Alternatively, an increase in height may enable the same area to be served by a lower power.

continued on page 38

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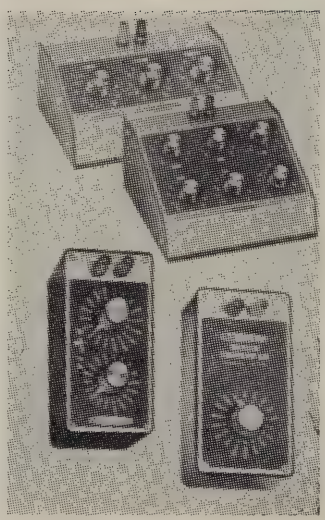
IN11 is a six decade resistance box with a 1% accuracy covering from 1 ohm to 999,999 ohms in 1 ohm steps. Most useful for design work.

IN21 is a three decade condenser box covering from 100mmfd to .111mfd 1% accuracy using silver mica condensers. Companion to the above.

PRICES: IN11, £16/7/-; IN21, £12/1/-.



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Philips TV Receiver —Panorama & Stockholm —Models 23CZ 324A, 23CZ 325A

RECEIVER ALIGNMENT

The 5.5 mc/s Sound IF

Apply a bias voltage of 3 volts between junction of R16 and C28, and ground (positive to ground).

Apply an unmodulated signal of 5.5 mc/s (preferably from a crystal oscillator) to point "R" of video detector via a 1K5 PF condenser.

Connect C43 (point K of sound detector) to ground.

Connect VTVM (—3 volt range) to junction R46-C44.

Contrast control to minimum, volume control to minimum.

Adjust for maximum meter deviation in the following manner, using a damping network of 100 ohms in series with 1K5PF where indicated. (Condenser always to cold end of circuit). Always adjust to correct tuning with slugs in top position in coils.

Damp across	Adjust	Meter
L3	L4-L5	Maximum
L4-L5	L3	Maximum
L2	L1	Maximum
C25	L2	Maximum

Now amplitude modulate the 5.5 mc/s signal and adjust L10 for minimum.

To observe the response curve, connect an oscilloscope to the junction of R46 and C44. Connect a 5.5 mc/s signal swept at 50 c/s over 400 kc/s to point "R" of video detector.

The 5.5 mc Sound IF Trap

Connect an unmodulated signal of 5.5 mc/s via a 3K3 ohm resistor to pin 8 of V10. Connect a VTVM between pin 6 of V10 and +3. Adjust the core of L42-L43 for minimum meter indication.

The Noise Invertor

Connect the oscilloscope via a detector probe to the junction of R54-C152. Inject a sweep signal, centre freq. 35.5 mc/s to pin 2 V14.

Set marker dial to 35.5 mc/s. Damp L33 with 1000 ohm in series with 1K5 PF adjust L34 for maximum height of oscilloscope trace at the marker frequency. Remove damping from L33 and connect across L34. Adjust L33 as for L34. The response curve should be steep sided and with the peak at 35.5 mc/s.

The Video IF

Turn channel selector to a vacant position (10-11-12). Turn contrast to maximum, brilliance to minimum. Apply a 6 volt battery between junction of C73-R52 and earth (positive to earth). Connect a VTVM between pin 7 and 8 of V10P set to —3v DC range.

Damp L33 with a 100 ohm + 1K5 PF to ground.

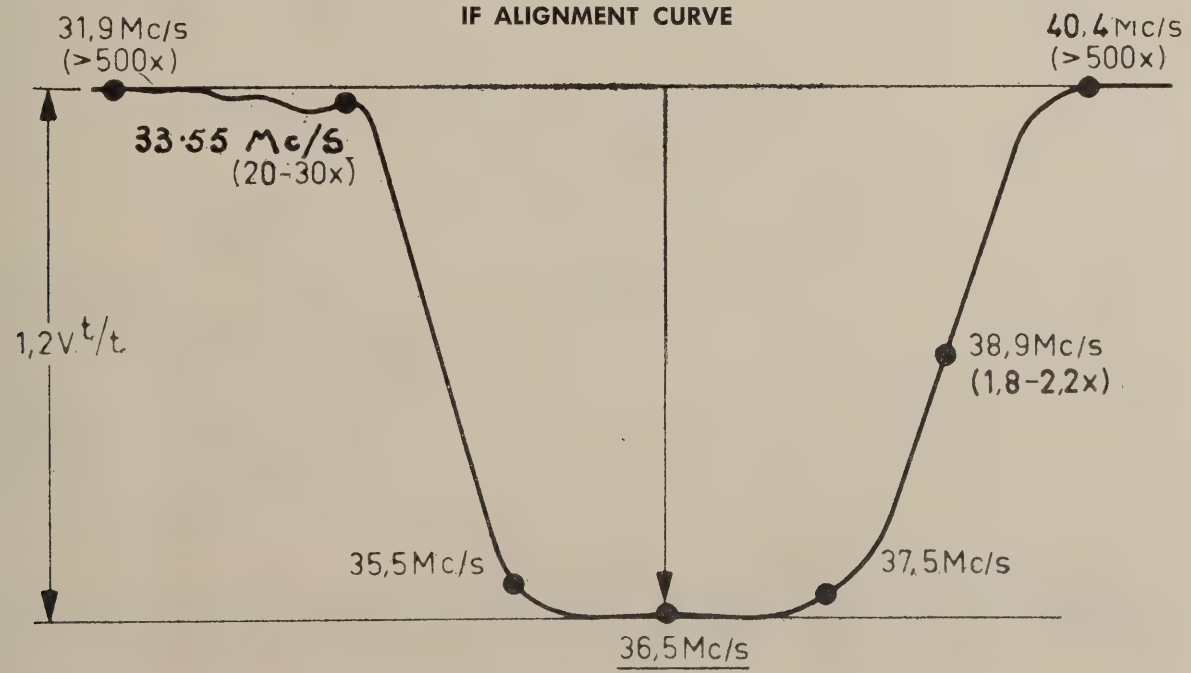
Apply an RF signal (marker generator) unmodulated to point "M2" on tuner (accessible through brass tube). Proceed as follows, using a damping network of 100 ohm in series with a 1K5 PF condenser where indicated (condenser to cold end of circuit). Always adjust to correct tuning with the slugs in top position in coils.

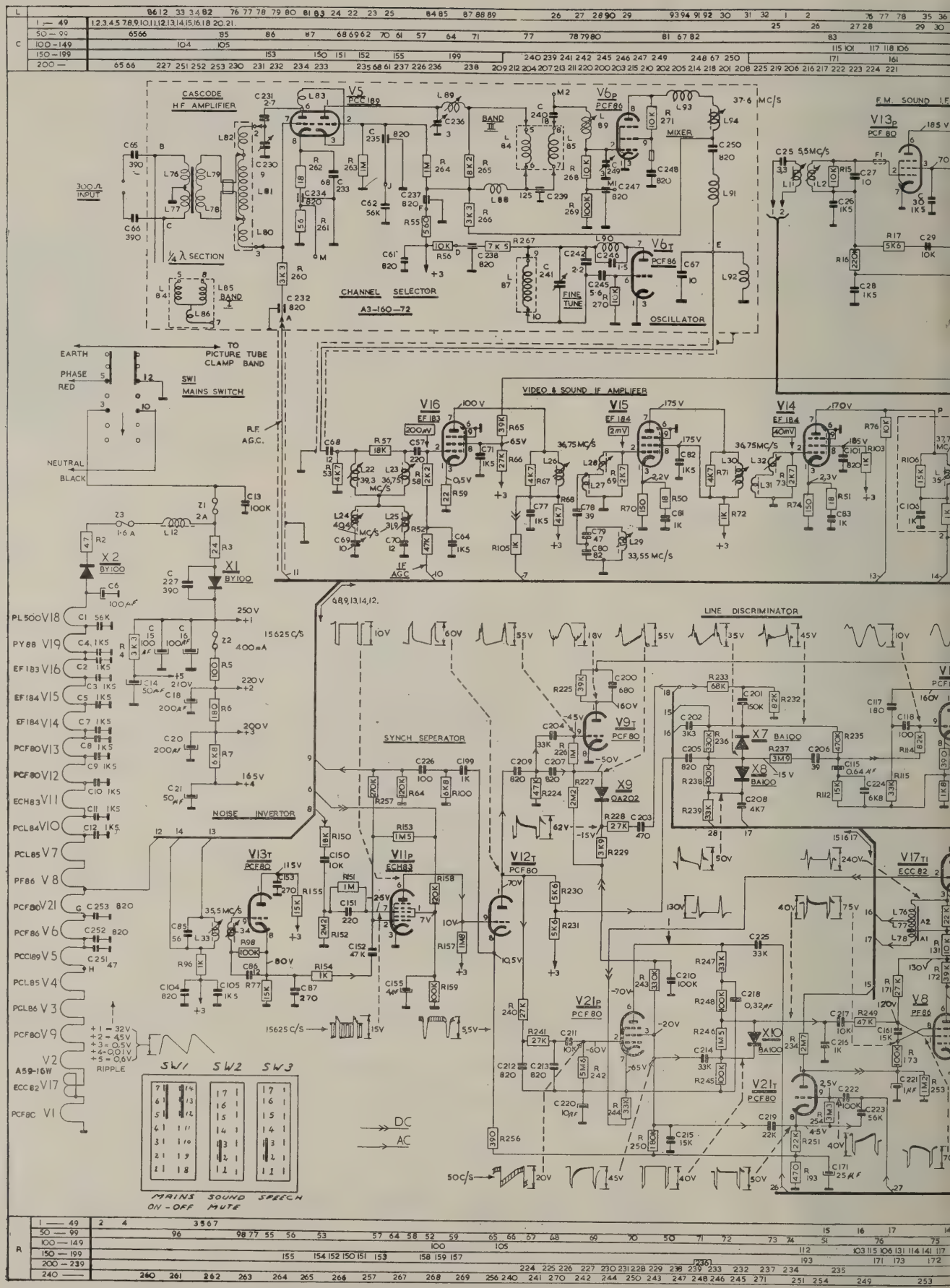
Damp across	Adjust	Freq.	Meter deviation
R81	L35	37.75	Max.
L35	L37	36.75	Max.
L31-L32	L30	36.75	Max.
L30	L32	36.75	Max.
L27-L28	L26	36.75	Max.
L26	L28	36.75	Max.
—	L29	33.55	Min.
—	L94	37.6	Max.
L24-L25	L22	39.3	Max
—	L23	36.75	Max.
—	L24-C69	40.4	Min.
—	L25	31.9	Min.
—	L94	37.6	Max.
L24-L25	L22	39.3	Max.
—	L23	36.75	Max.
—	L24-C69	40.4	Min.
—	L25	31.9	Min.

Checking the Response Curve

Leave bias battery, and damping across L33 in place. Connect oscilloscope to pin 8 V10P. Connect sweep generator to point "M2" on tuner (centre freq. 36 mc/s sweep 10 mc/s at 50 c/s). The response curve should be as shown.

IF ALIGNMENT CURVE

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EARTH
PHASE
RED
NEUTRAL
BLACK
TO PICTURE TUBE CLAMP BAND
SW1 MAINS SWITCH
300Ω INPUT
¼λ SECTION
FINE TUNE
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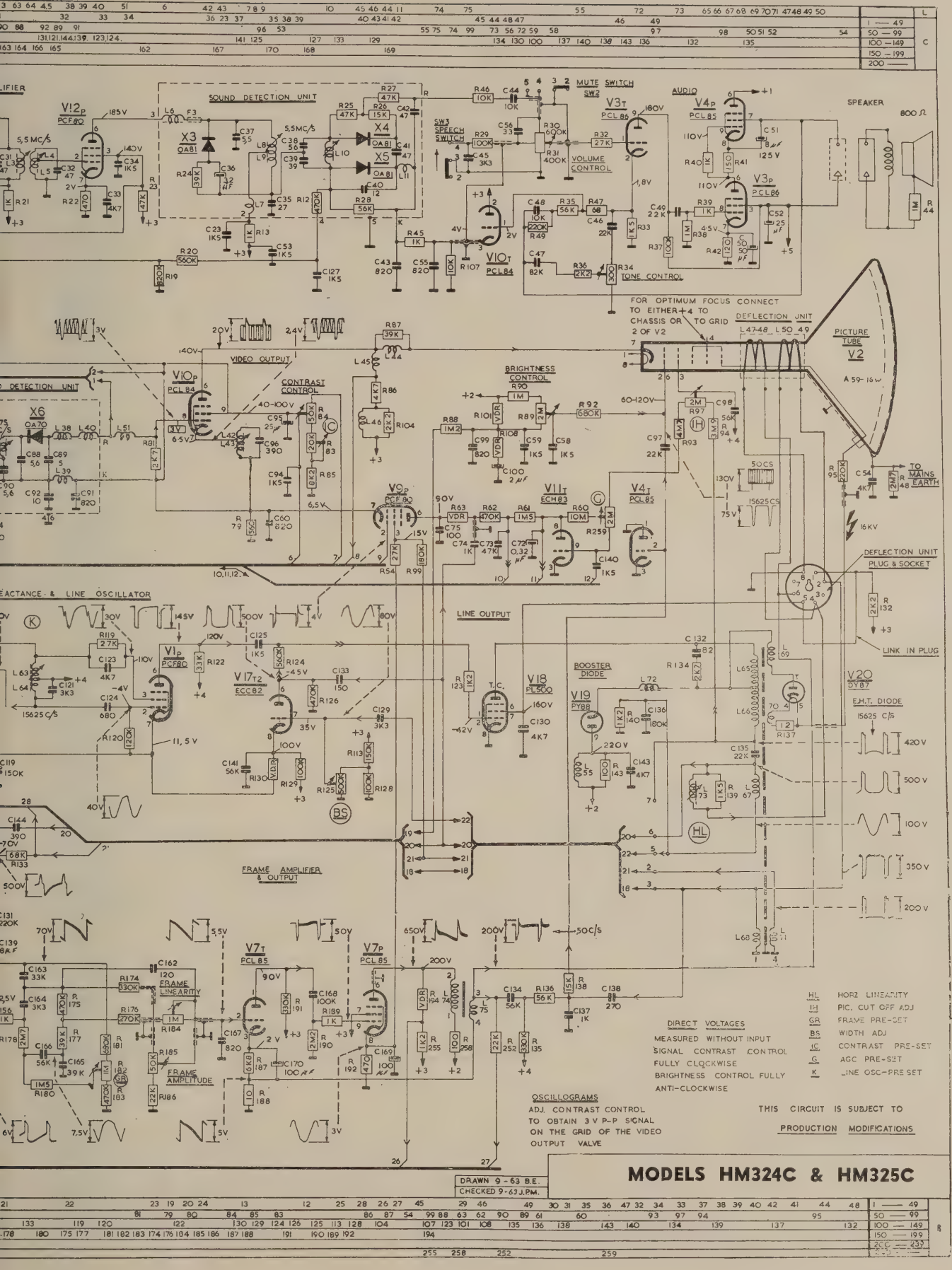
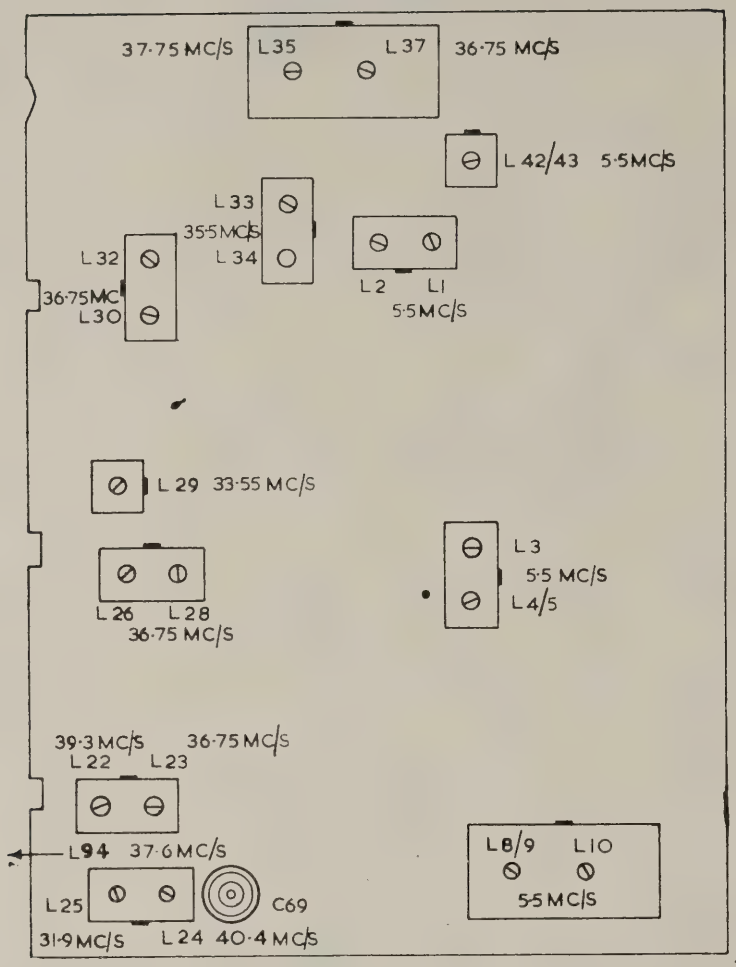
DC
AC



MODELS HM324C & HM325C

COIL LOCATION



General Service Notes

The voltages indicated on the circuit diagram have been measured with a vacuum tube voltmeter having a high internal impedance. When instruments having a lower internal impedance are used the voltages indicated will in many instances be somewhat lower than shown. The readings shown are the average values of a number of receivers and may vary by ±5 per cent. The receiver should be adjusted for normal picture, then the signal removed and the brilliance control turned to minimum and contrast to maximum.

Before commencing service on the receiver check that the mains plug is correctly wired and, with a neon indicator, make sure the metal chassis is not connected to phase. When replacing the picture tube always wear safety glasses.

In view of the high tensions in the line output circuit take care when measurements are being carried out.

When the chassis is clear of the cabinet on the service bench and the picture tube is connected, make sure that the conductive coating on the outer surface of the rear of the picture tube is connected to the metal chassis as the surface can charge up to the E.H.T. voltage.

A safety link is incorporated in the deflection unit plug which removes the screen voltage from the line output valve to avoid accidental burning of the picture tube screen.

ACCESS TO CHASSIS AND CONTROL PANEL
Model 23CZ324A

Chassis

(a) Remove rear panel of receiver by loosening 7 holding screws then slide panel downwards and away from cabinet.

(b) Chassis is now exposed for service.

(c) To obtain access to rear of panels undo screws in nylon blocks at top right and lower right side of chassis assembly. Swing chassis out to desired angle for service.

Note.—Maximum angle 70° without removing leads to picture tube and yoke.

Control Panel

(a) As above, swing chassis out.

(b) Remove knobs from shaft. Switch knobs remove with panel.

(c) Unscrew holding screws under cabinet.

(d) Withdraw control panel.

To refit panel into cabinet and locate shafts through mask, insert lengths of tubing through holes in mask. Insert shafts into tubing and locate control panel in position, then withdraw tubing from front of cabinet and fit knobs to shafts.

ACCESS TO CHASSIS AND CONTROL PANEL
Model 23CZ325A

(a) Remove screws from bottom of rear panel slacken off side screws slide brackets in slots towards centre of panel and draw panel away from cabinet.

(b) Chassis is now exposed for service.

(c) To obtain access to rear of panels undo screws in nylon blocks at top right and lower right side of chassis assembly.

(d) Swing chassis out to desired angle for service.

Note:—Maximum angle 70° without removing leads to picture tube and yoke.

Control Panel Access

(a) Remove rear panel of receiver as directed in (a) above.

(b) Remove green wire from tube support band.

(c) Remove four screws from rear corners of control panel.

(d) Withdraw control panel carefully, as mounting spacers behind panel will be released.

PRODUCTION MODIFICATIONS

Control Shafts 324—Contrast, Brilliance, Volume, Tone

Initial production models had a split-pin coupling for attachment of extension shaft to the control. This method of coupling is now modified to a spring unit. Should controls of the original type require replacement then both extension shaft, spring and control should be ordered.

Video Response—23CZ324A, 23CZ321A, 23CZ325A

In early production models it has been found that the video response may be improved by alteration of the video correction coils L44 and L45. These should be replaced with video correction coils code number A3 98627 in both cases. All present production has this correction incorporated.

When changing these coils care should be taken to remove flux from the printed board. This will ensure that no undue stray capacity is located in the video plate circuit.

Mask Mounting Model 23CZ324A

MK I: This is the original mask fitted to production and may be identified as MK I by the absence of holes drilled in the front rim of the cabinet.

MK II: Production was changed as from November, 1963 onwards and this mask may be identified by the incorporation of mounting holes drilled in the front rim of the cabinet to support the mask.

When changing the mask these factors should be studied before forwarding your order for a replacement unit.

SERVICEMAN'S COLUMN

Conducted by J. Whitley Stokes

In the January issue of R. & E. I made reference to an article dealing with dishonest servicemen which appeared in the Readers' Digest in 1940. To many this may have seemed like digging up the past but as a matter of interest I chanced across reference to this very same article in a recent issue of an overseas publication. This was an article in the May 1964 Electronics World, by that veteran service writer John T. Frye, entitled "The Fraudulent Technician—a Minority." I would like this to be required reading for all individual organisations who may be planning any investigations into unethical practices in any field of servicing. I would also like to quote the following passage from Mr. Frye's article:

"Last summer on vacation my car began to miss, and I took it into a garage. The mechanic first put in new points. Then he installed a new condenser. Next he cleaned and adjusted a carburettor. Finally he replaced a resistor-type spark plug wire, and **that** cured the trouble. Actually all I needed to stop the missing was that new wire, but I had to pay for all the rest. And I must admit the points were rather badly pitted, the condenser showed a little leaky, and the carburettor had some dirt in it. Any one of these things could have been causing the difficulty and likely would have given me trouble later; so I paid the bill without bellyaching. I didn't feel the mechanic was trying to cheat me, and I hope he would give me the same consideration if I were working on his T.V. receiver."

EHT Rectifiers

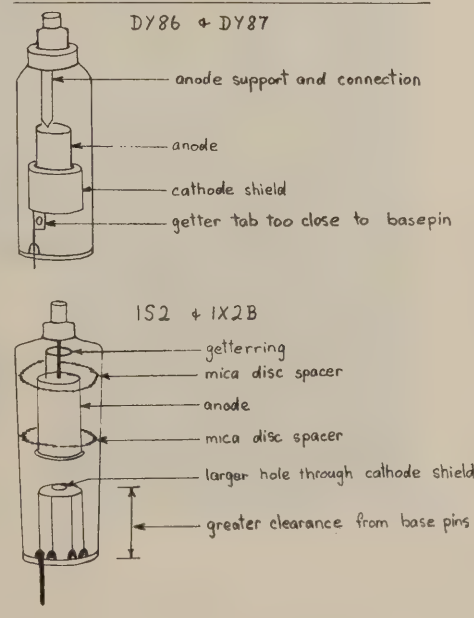
Having trouble with DY86's and DY87's? So was I. It happened like this. Needing a new DY86 for a T.V. repair in the shop recently I just took one off the shelf and inserted it in the set. No joy, the filament didn't light up. Well that could mean other trouble of course as the original faulty rectifier was shorted from plate to filament. However, I just had the feeling that the new rectifier was faulty and a quick check in the valve tester confirmed the fact. A second new one off the shelf exhibited the same symptoms. Two faulty new ones in succession—oh well it happens sometimes—just a question of percentages or something. Third time lucky (perhaps). But it wasn't. Yes, the third, and last one left was faulty too.

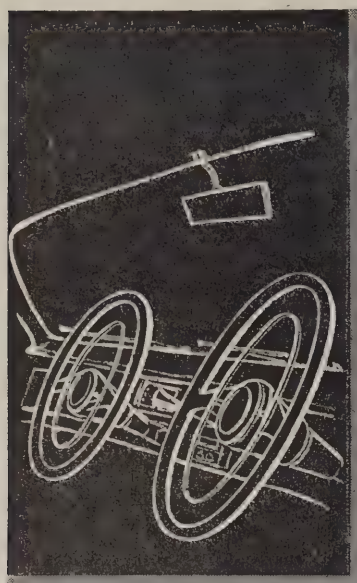
Well, after that I decided that three in a row was a bit too much of a coincidence and put all defective ones to one side with the idea of doing a bit of investigation of the matter when time permitted. Since then I have duly taken a close look at things, and this is what I found.

Two of the faulty valves were of Dutch manufacture and one German. The latter and one of the former had shorted filaments, on the surface of an unlikely state of affairs so I got out a magnifying glass and examined the electrode structure carefully in each case. In the first case the lower end of the filament support wire could be seen touching the side of the hole in the centre anti-corona shield through which it passed. In the second case the getter tab attached to the bottom edge of the shield could be seen in contact with pin no. 2. The remaining Dutch valve had no shorts but nevertheless the filament would not light so I came to the conclusion that there was an air leak present for although there was no sign of a crack in the glass adjacent to any of the pins, there was a small fragment of glass loose inside the bulb. Furthermore it could be seen that some of the glass was broken away internally where the anode rod support was attached to top of the bulb. As a matter of interest I also had a look at one valve of English manufacture and found that it differed in having no getter tab attached to the anti-corona shield but having instead a getter **ring** attached to the anode support rod near the top of the bulb. Incidentally the getter material appeared to be different too as there was that darkish deposit one associates with barium getter whereas with the other valves there were no getter deposits to be seen. After that I decided to compare American designs with European and I must admit I got quite a pleasant surprise. Previously I had on occasions used the American types 1X2B to replace a DY80 and 1S2 to replace DY86 and 87 on the assumption that one was as good as another. However, as a result of my observations I now consider the American types to be vastly superior in electrode design and assembly at least, and I now intend to use them exclusively.

The most obvious difference with the American types is that the anode is not merely held in position by the two top support rods but also has two concentric mica spacers surrounding the anode and maintaining it rigidly in position. Furthermore, the anti-corona shield is in the form of a disc, unlike the "top hat construction of the European types and most important the centre hole through which the lower filament support passes is about twice as large thus giving a much greater clearance. Reference to the sketch should make things a bit clearer (I hope).

Owing to an error there was no definite indication where Mr. T. C. King's material finished and mine began last month. The division should have been after the second paragraph in the 3rd column, page 23 (". . . . selling of new sets").





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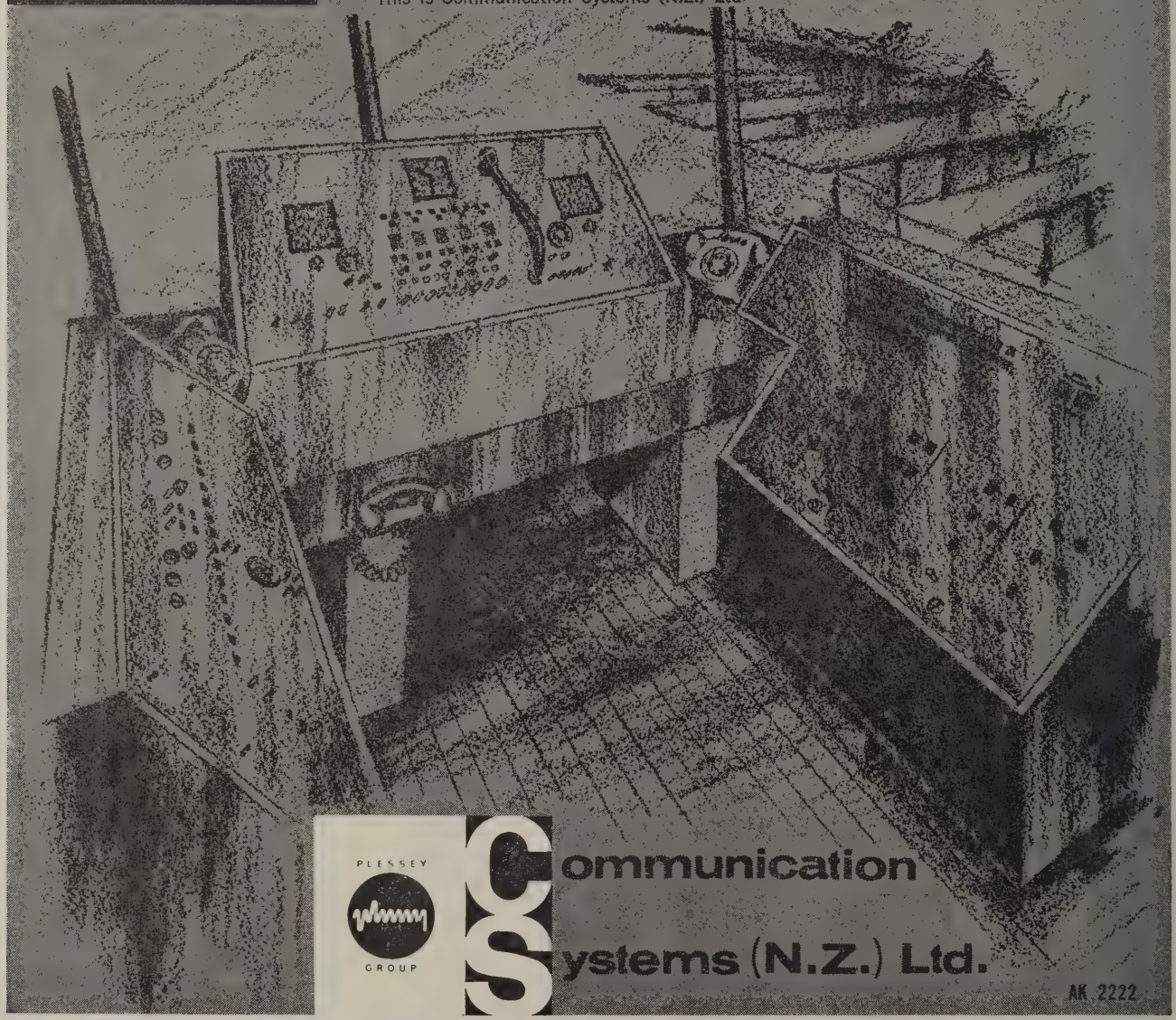

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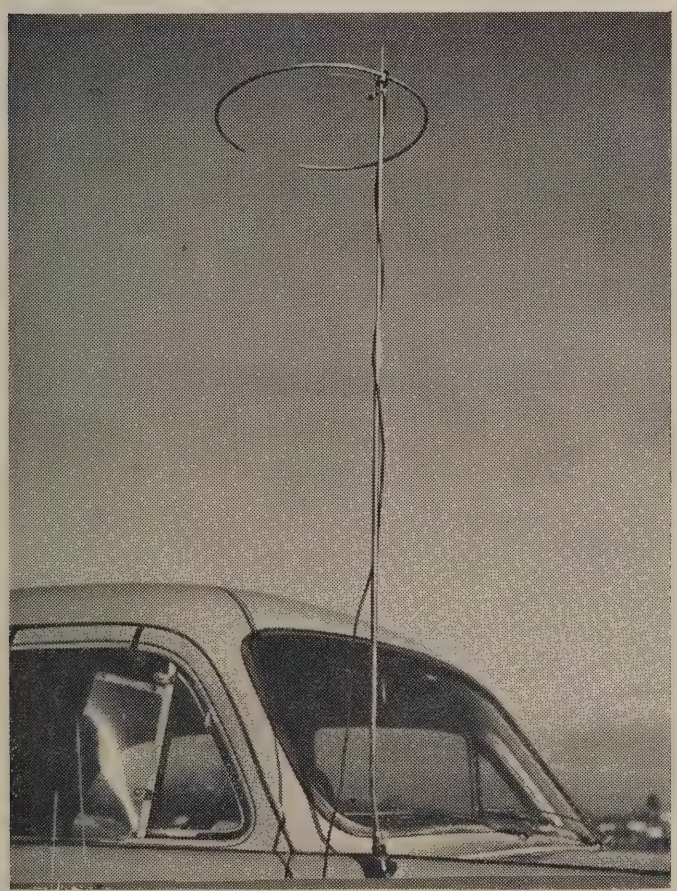
Some Aspects of V.H.F. Mobile Operation

by Irving Spackman, ZL1MO

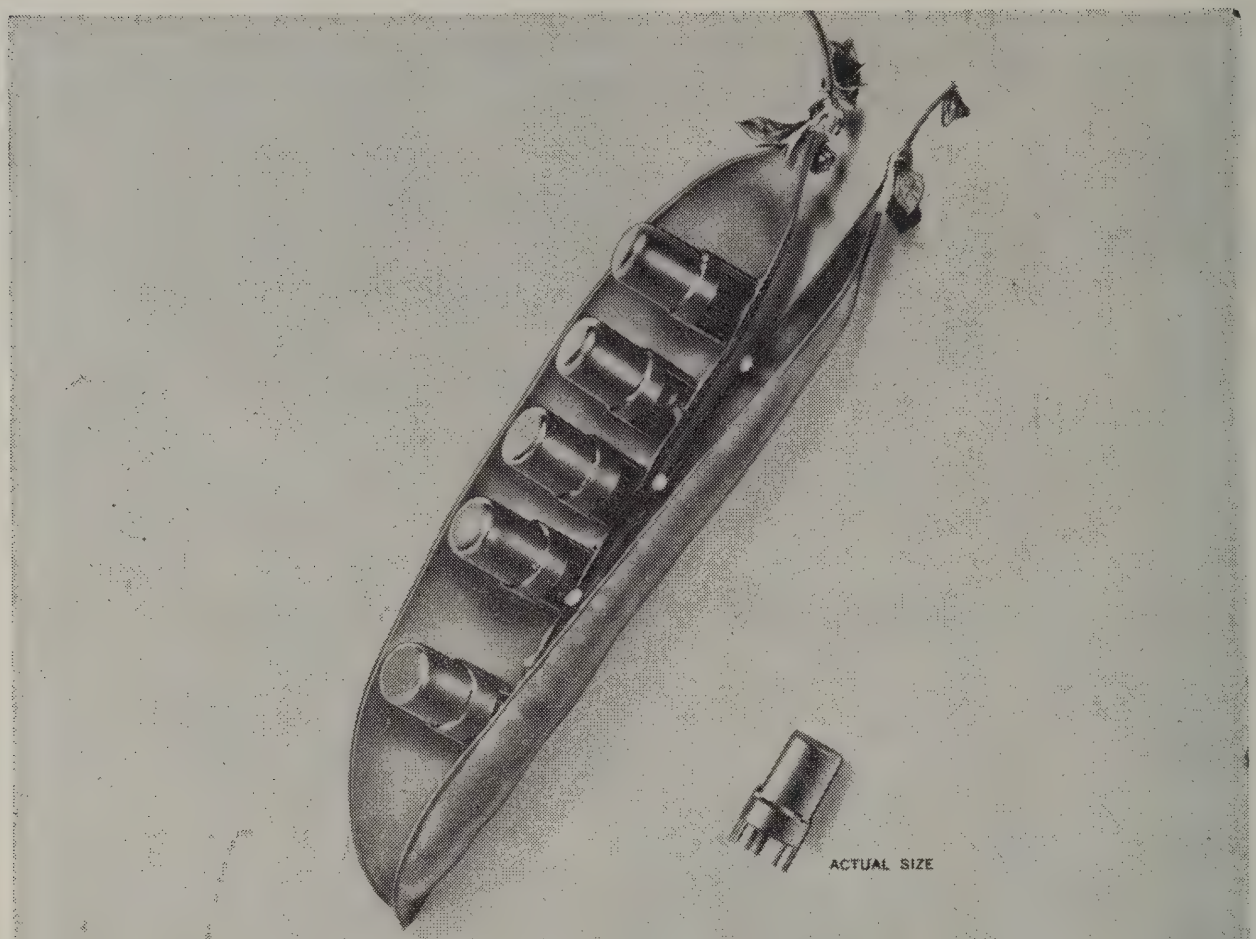
Right: Turnstile Antenna Mounted on Car Broadcast Whip.

Below: Halo Antenna similarly mounted.



We show on this page photographs of two of the antennae described on page 14 of April issue. Unfortunately we have been unable to continue the series this month owing to pressure of space. Next month, however, we will be featuring the tunable receiver aspect of the mobile installation.

EDITOR'S Note: Readers are recommended to turn to page 27 for details of a power supply unit for testing transistorised mobile equipment when the vehicle is not handy.



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RCA-7587**	general-purpose sharp-cutoff industrial tetrode	12,200	9,000
RCA-8056	medium-mu triode for low voltage power supply and small-signal amplifier applications up to 350 Mc.	8,000	6,000
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*with 6.3 volts ac or dc on heater **tetrode, dc grid #2 volts = 50

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VR.22

A Transistorised Low Voltage Regulated Power Supply

by Irving Spackman ZL1MO

During the course of development and testing of V.H.F. and M.F. mobile equipment for the series which is currently running in this magazine, the problem arose of powering equipment which is basically designed to operate from 6 or 12 volt storage batteries. This problem is not great if batteries are handy or the vehicle is garaged nearby. However, in the author's case the workshop and the garage are at the opposite ends of 180ft. section, and the time and energy expended in moving the battery around became of more than average proportions.

Thus this supply was produced to fill a very real need, and in describing this unit, the author has in mind the many servicemen, amateurs and auto electrical workers who have need for a source of adjustable voltage up to 15 volts with current capability of 2 to 4 amperes.

The regulation of the output voltage is suitable for most applications, except the most critical. In the worst possible case, a variation of load current from zero to three amperes, causes a variation of a little more than half a volt, with the output set up at 12 volts.

The unit is basically powered from a battery charger transformer. There are at least two units suitable for this supply—the Beacon type R77 at 2.5 amperes, or the type R78, capable of 4 amperes output. By switching between the 6 volt or 12 volt section of the winding, and using a bridge rectifier of 4 silicon semiconductor rectifiers, a supply voltage of about 8 or 16 volts is produced at the output of the rectifiers, measured across the reservoir capacities.

The regular section of the power supply uses a series transistor regulator employing two power transistors type 2N301, in parallel, to provide adequate dissipation and to pass the full load current of 4 amperes. If the R77 transformer is used with its 2% ampere capability, then only 1 of the 2N301 transistors is required in the series element.

The reference source for the regulator is a Zener diode type OA216/12. This holds the base voltage of the 2N217S emitter follower at a fixed voltage,—the emitter assures a voltage very close to this, due to the "follower" effect. The variable voltage control is placed in the emitter circuit and the 2N217S operating in this mode effectively isolates the control voltage and the Zener diode from the remainder of the regulator system.

In addition, the 100 mfd. capacitor, in the base circuit of the 2N217S ensures that the control voltage is almost "ripple free." Thus the control voltage potentiometer becomes a source of variable but regulated and filtered voltage, and allows the base of the following 2N301 control amplifier to be adjusted over a range of 0-6 or 6 to 12 volts, depending on the position of the voltage range switch.

No measurements have been made on the ripple voltage present in the output of the unit, but several transistor amplifiers have been operated from the supply without any sign of "hum" appearing to originate in the power unit. Figures quoted for other power units of similar design, are, however, in the vicinity of 10-30 mv. at 12 volts output.

Readers will note that the voltage changing switch selects either 8 or 16 volts from the rectifier, and sets up the voltage across the emitter follower to be a variable 0-6 volts, or 6 to 12 volts. However it should be noted that the Zener diode and 2N217S emitter follower are permanently connected across the 12 volt section of the supply. The reason for this is that a suitable pair of 6 volt Zener diodes was not available at the time this unit was constructed, and this method does save the cost of 1 diode (at the expense of an extra resistor). The extra switch contacts were available on the switch which is a standard 4-pole 3-position rotary wafer and readily available.

The rectifiers, R.C.A. type 40108 are industrial types (hence the unfamiliar number—not of the 1N . . . series). Rated for 10 amperes at 50 volts P.I.V., these diodes are compact, reasonably priced and currently available, as they are part of a standard stock line.

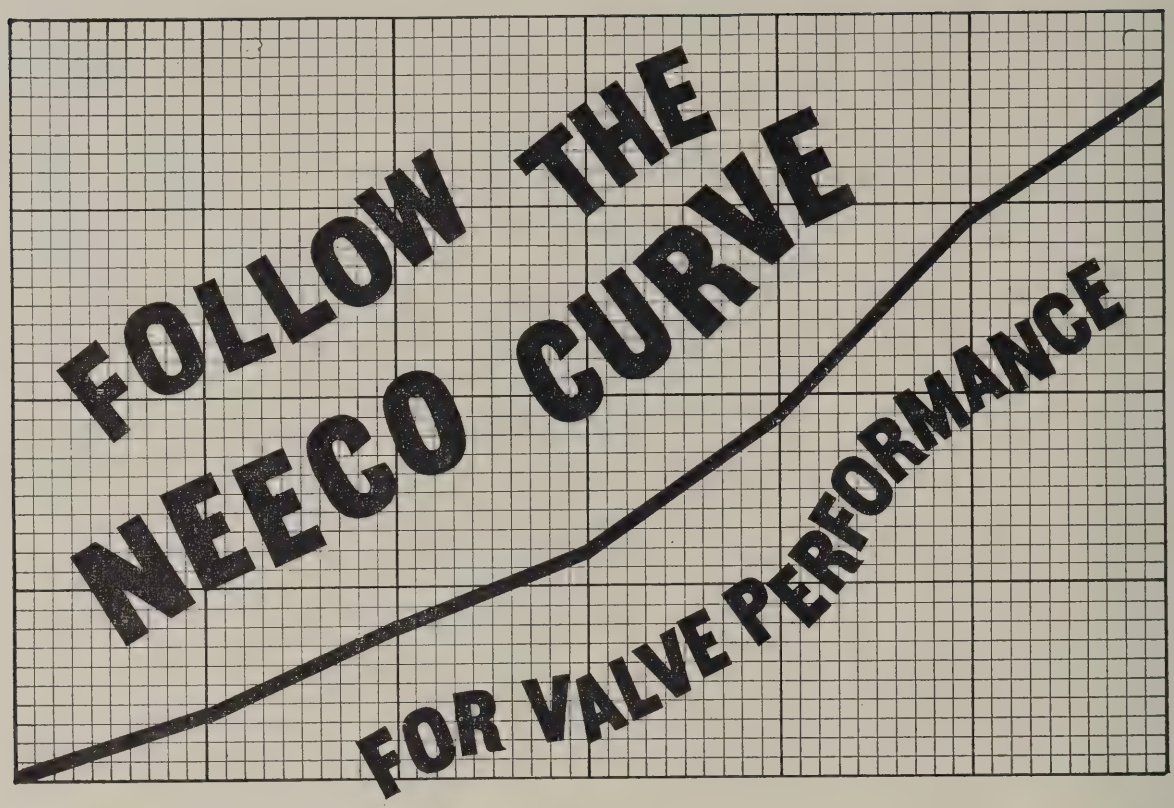
Construction

The unit is built in a small case, with the power transformer, rectifiers and the three power transistors mounted onto a small sub-chassis fixed at right angles to the panel. This chassis serves as a heat-sink for the transistors, and therefore should not be painted.

When mounting the rectifiers and transistors, mica washers are used to provide maximum heat transfer, with the necessary D.C. insulation. Care should be taken to see that no burrs or filings from the metal-work are left around the holes over or through which the semiconductor units are mounted, otherwise there is a likelihood of the mica washers being punctured or damaged with the outcome being a short between semiconductor and chassis.

On the front panel are mounted in a logical and symmetrical fashion, the switch for power, 0-6 or 6-12 volts, the voltage control potentiometer, and the ammeter shunt switch; the volt and ammeter, a neon "power-on" warning light, and the output terminals (both insulated from the chassis and cabinet). These terminals should be labelled or colour coded for simple identification.

After the unit has been completely wired, and is ready for switching-on, it is a sound idea to check all the connections, with the circuit thoroughly, particularly the polarity of the meters and electrolytic capacitors, and the connections to rectifiers, transistors and Zener diode. Check with an ohmmeter for any shorts from condensers or other parts to the chassis or frame.



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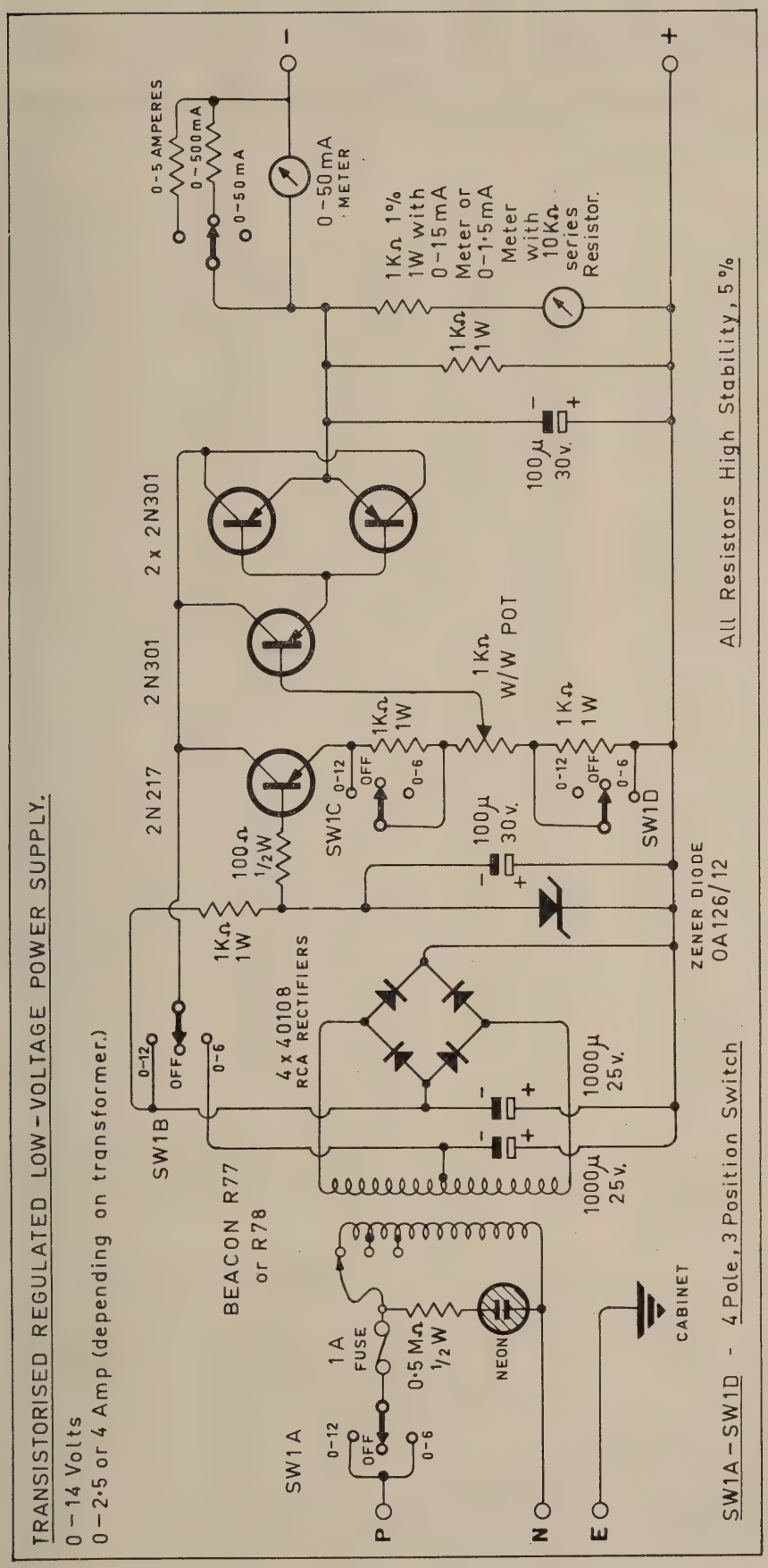
V2.1



Before applying power turn the unit to 6 volts with the voltage control potentiometer in the off position. Check with a meter to see that voltages are correct, that the Zener diode is regulating and that there are no obvious troubles. Then the control can be advanced and voltage should show on the meter. See that under the no-load condition, the voltage can be varied over the required range, as selected by means of the voltage range switch. Loads of various sizes can then be connected to make sure the unit will then deliver the required output current.

The uses of this instrument are quite obvious, but care should be taken when connecting apparatus to the power unit. Whilst the output of the unit is isolated from earth, thereby allowing either side to be grounded as required, it is sound practice to apply the earth only at the equipment the supply is operating, to avoid any likelihood of short-circuits. No fuse is incorporated in the outputs, although one could be included if desired, because of the fact that a 4 ampere fuse is no protection for a 100 mA. system, whilst a 500 mA. fuse will not pass 4 amperes. It is hoped to include electronic short circuit protection in this unit at a later date, but it was not included in the unit as described for reasons of economy and expediency. The best protection for the unit and apparatus connected to it is "CAUTION." If there is any doubt about a possible short, connect a few ohms of series resistance in series with the system. At low load currents, this resistance can be left in circuit as the voltage lost can be made up by the unit, except at the extreme upper range of voltage settings. After the equipment is operating satisfactorily, the series resistance can be removed and the voltage readjusted—no harm having been done.

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N.Z.B.C. REPORT

Concerning Technical Facilities At Broadcasting House, Wellington

PART III

Report prepared by:—
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(c) The Master Control Room

This room contains a total of sixteen cabinet type equipment racks arranged in the form of an "L". Rear doors are not employed on these racks as the area behind is completely enclosed and accessible through a door provided at one end of the room. The whole room is air-conditioned. In the centre of the room, facing the long section of the rack bay, is the large supervisory control desk. This desk contains the controls for the major circuit switching systems, the visual and aural programme monitor controls, the talk-back system and all the telephones and communications selectors.

The remote control panel for the building ventilation system is also wall-mounted in this room as also is the building fire detector display panel.

Dealing first with the Master control room desk, the large sloping turret which forms the main panel contains three sections. On the extreme left is a large push button crossbar switch which forms the main Programme Distribution Selector. This is built up of thirteen rows of eleven position interlocked switchbanks arranged with the interlock in the vertical plane. Each horizontal row of push buttons represents a programme source which read, running from top to bottom, Suites 1 to 8, Parliament programme from the House of Representatives, a spare position and finally the "off" position for each switch-bank on the extreme bottom row. These switch buttons are illuminated when depressed. The vertical switch rows are colour-coded by a plastic back-mounting strip and these indicate the particular station transmitters 2YA, 2YC, 2ZB etc., or the circuit designation, e.g. "National Programme." In effect, each vertical row feeds a group of distribution amplifiers, each group of which is permanently allocated to a specific station or function, e.g., 2YA, National Programme, etc., and this panel enables the routing of programmes to the desired transmitters, no matter from which suite they originate. Depression of any one of these switch buttons effects the multi-circuit switching already described under Suite Control Room facilities.

Below the crossbar switch is a row of key switches by means of which the automatic Time Signals can be switched to a station's transmission. A V.U. meter with push-to-read selector buttons, allows for "spot checks" on the Suite programme lines entering the crossbar panel and for checks of the programme on the outgoing transmitter lines, which is the final check point. An audio monitor selector associated with this panel is provided in the desk top immediately below the crossbar switch and provides for selection of either "National" or "Local" programme from each of the suites or programme sources.

The centre section of the Master control desk panel is another pushbutton crossbar switch, even larger than the previous one and this routes programmes to the long distant line circuits and a total of eighteen toll line circuits. The vertical rows are the programme sources on which the colour-coding is again repeated. Reading from left to right, we have two National programme circuits, the six incoming wide band programme lines, to enable "route through" of these to distant stations, then the five Wellington broadcasting station programmes and the two Radio New Zealand programmes, three circuits labelled "utility" which are spares for any future additional stations, six programme sources originating from Central Recording Section in Broadcasting House and finally two more spare circuits with the replay of a tape recorder located in Master control room on the final extreme right hand vertical pushbutton row. Here again, all pushbuttons are illuminated when depressed. Though somewhat overpowering to look at, due to the size of this panel, it is relatively simple to operate. Visual monitoring is provided by means of a row of eight V.U. meters arranged along the top of the switch panel. Of these, one is for "spot checks" on the switch input circuits, i.e., the programme source lines, the next six meters are permanently across the outgoing wide band programme line circuits; one meter for each line and the final meter can be switched to any one of the eighteen toll lines.

Another audio monitor selector is provided in the desk surface immediately in front of this panel for checking on outgoing lines. This selector feeds a second monitor loudspeaker in the Master Control room.

The right hand section of the control desk panel is the "External Line Communications Switch" whose function is to set up these circuits for telephone communication purposes. On this panel the wide band line circuits can be switched from the programme "mode" and the incoming and outgoing lines routed to a hybrid coil from which they emerge as a two-wire circuit for telephone communications. These lines can also be directed to either of two Conference Call circuits simply by operation of one pushbutton on each of the desired lines. In this instance, all the necessary "route through" is done automatically by means

of relays controlled from the one pushbutton without the need for extensive circuit patching on a jackfield. There is also means for extending the wide band lines to the Broadcasting House P.A.B.X. operator's switchboard for communication purpose during periods when the lines are not engaged for programme. A somewhat comprehensive system of signal lamp indicators are supplied on this panel to warn the Master Control operator when any of the lines, either inward or outward are engaged on programme. There is also means for switching some twenty-four toll circuits to manual telephones. It should be appreciated that these circuits are in reality, waylines to the Wellington Post Office Carrier Room where they are there connected through to the desired toll circuits to or from distant stations throughout the country.

The Master control room telephone facilities comprise an automatic circuit with two telephones, one on each end of the desk top and five manual type telephones mounted verticaly on a telephone panel extension wing at the right hand side of the desk. Of these, one is a permanent connection on the Wellington Post Office exchange; one, a transmitter phone routed via selector keys and there are two phones — one for each of the two Conference Call circuits whilst the fifth serves the outside broadcast lines. The transmitter telephone is duplicated on the left hand side of the desk also and the outside broadcast telephone can be switched over to another located on Rack No. 16.

A table shelf assembly is supplied across Racks 15 and 16 for use during busy outside broadcasting periods as the main outside line jackfield is located in Rack 16. Single jacks of the tip, sleeve and ring type are used throughout. This jackfield contains some 576 jacks. A line testing unit providing for line loop tests is in the adjacent rack and a total of ten N.Z.B.C. variable equalisers are supplied in nearby racks. These allow for the setting up, checking and equalisation of all outside broadcast lines prior to their handing over to the stations required to originate the broadcasts.

The Master control room talkback system enables communications with all Suite Control rooms and Studio sub-control rooms throughout Broadcasting House, together with circuits to the Duty Office, Central Recording, the P.A.B.X. telephone operator and an "all call" circuit. The talkback microphone, loudspeaker and selector switch are incorporated in the Master control room desk but two further answering positions together with loudspeakers are provided at each end of the equipment rack bay. For the latter, a carbon type microphone with press-to-talk switch is provided hanging from a hook on the rack panel. Selection of circuit must, however, be first made from the desk panel.

The two high quality monitor loudspeakers are housed, one above the other in a special compartment angled towards the control desk, at the extreme left hand end of the rack bays.

Almost the full space in all sixteen racks is taken up with equipment such as distribution and isolation amplifiers and their power supplies, line equalisers, relay panels, the uniselector switches, jackfields, 50v. D.C. signal power supplies, time signal equipment and the Quart Crystal Master Clock which controls all "slave" clocks throughout the building. Other racks contain the transmitter remote control units, limiting amplifiers used on long distant line circuits, the station monitor receivers, of which there are a total of seven, the echo plate selector switches and much other equipment.

At the rear of the racks are the two large cable distribution frames, one terminating the Post Office cables for the external lines and the other the N.Z.B.C. cables distributing to and from all the operational areas in Broadcasting House and linking to the Master control equipment.

The Master Control Room is manned for twenty-four hours per day, as 2YA now provides an all-night transmission. A single technician can cope in the Master Control Room during slack periods but two to four technicians would be on duty during busy periods.

We will shortly be installing a voice frequency selective calling system for our long distance line circuits. The equipment will operate in the 3-tone sequential made on frequencies with the range of 1100-2900 c.p.s. The 3-tone system is employed to ensure against false operation from programme information such as music, etc.

The code generator will be fully transistorised and is contained in a small sheet metal case, suitable for desk top mounting. It is operated from ten digit push-buttons plus a push to operate switch and is capable of some 120 different codes.

The decoder, also transistorised, is of small dimensions and will be for rack mounting. In the case of Broadcasting House, some eighteen decoders will be installed, one for each of the six wide band line circuits and twelve for use on toll line circuits.

This equipment is being manufactured locally for the N.Z.B.C. and when installed will enable coded ringing between N.Z.B.C. stations throughout the country, even over the top of any programme that may be on the line, when this is necessary.

(d) Central Recording Facilities

This section is not yet in operation at Broadcasting House as the N.Z.B.C. decided to review the requirements since 1960, in the light of present-day commitments. As a result, these facilities have been re-designed and the new equipment should be available early this year.

The proposals are to provide a total of sixteen magnetic tape recorders for the main recording room, each with an associated Recorder Control Unit of N.Z.B.C. design. The Recorder Control units will be moved from the present Saywell's Building (Wellington Recording Centre) and after modifications and renovation transferred to Broadcasting House. Ampex Model 351 Professional type tape recorders will be employed. Some six cabinet type racks together with transistorised rack-mounting amplifiers and other equipment inclusive of a small control desk for the recording room and the complete facilities for the two Recording Suits Nos. 10 and 11 are now on order from Japan.

The final system will be such that some twenty-

six programme sources, supplied via a "bus" circuit around the recording room will be available for selection to the recorder inputs on each Recorder Control Unit panel. In addition, a further thirteen programme sources will be obtainable by pre-selection from a crossbar switch feeding each of the sixteen recorders. This switch will be located in one of the equipment racks. Facilities will also be included for recording from outside broadcast lines routed through the Master Control Room and a manual telephone on each of the Recorder control units provides means for communications to the remote relay point. Signal lights on the control unit panels indicate the mode of operation, i.e. recording or replaying of each particular recorder and the line circuit on which it is engaged. "Line busy" lights operate simultaneously on all control units. Other facilities on the Control units include mixers on each alternate unit, to enable cross-fading between adjacent recorders during replay.

For the recorder motion control, two "master bus" circuits will be available, to which any of the recorders can be switched. When this is done, the "start," "stop" operation of all recorders switched to the particular "master bus" circuit can be controlled from the control unit panel of any one of the recorders so switched or from the control desk situated in the centre of the room.

The control desk here includes a four channel mixer to enable "dubbings" from disc or tape recordings to be made. Two turntable units and tape replay facilities will be associated with the desk, also a microphone circuit for instructions to be recorded on the start of tapes. The desk will also provide an audio monitor selector switch to allow for any recorder replay to be selected for critical listening checks on a quality monitor loudspeaker. A medium quality monitor loudspeaker will be provided, ceiling mounted, or immediately above each recording position around the room but these are intended for "spot checks" only.

The two recording Suites located on the same floor, adjacent to the recording room, will each have control desks and an eight channel mixer console in their control rooms together with transcription turntables and tape recorders. Echo facilities will also be provided on these mixers. The associated Talks Studios will be similarly equipped to those of the Station Suite Talks rooms. The Recording Suites are not directly connected to Master Control room and serve the Central Recording Section only.

e. Other Technical Facilities

For office monitoring purposes, a programme "ring-main" system is provided around all floors of the building. This comprises fifteen low impedance circuits each of 20 ohms fed from distribution amplifiers in the Master Control Room. As the offices are located round the outer perimeter of the building and as the office heating vector panels are arranged around the outer walls of the building, ducts were provided in these panels for the "ring-main" cables.

Monitor selector and loudspeaker gain control panels, supplied from Japan, are mounted in the

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building vector panels in the offices requiring the facilities. Some seventy of these were installed. The office monitor amplifiers bridge across these circuits. The eleven position monitor selector switch enables any station programme to be selected plus a choice of three other circuits and the final position is designated "local." For choice there are three "utility" circuits and two "National Programme" circuits available, the three required by the particular office are wired to the selector switch. The "local" position is for a tape or disc play unit which may be used within the office, and the unit's output can be plugged into a connector provided on the selector panel and thus routed to the office monitor loudspeaker. This "ring-main" system also serves the public lounges and waiting areas.

An interesting feature concerns the receiving aerials for the station monitor receivers in the Master Control Room. As it was not desirable to provide unsightly outside aerials to mar the overall appearance of the building, we looked for another solution. Six metal flagpoles atop the adjoining ten storey Bowen State Building offered a possibility and these were investigated. The poles, some 25 feet in height, were insulated from the building structure and all six are bonded together by metal braces. A twin aerial lead was taken down the building service duct to the basement and thence across the Link Block into Broadcasting House where it terminates in the Master Control Room. Tests proved that ample signal strength was available on all stations without the necessity for a wideband amplifier and what is more, it proved remarkably free from interference and noise. It was only necessary to provide "spliting pads" to feed the seven receivers plus transformer coupling for the "lead-in" cable.

Three grades of loudspeaker are employed in Broadcasting House, Grade "A" for critical listening positions, e.g., control rooms, sub-control rooms, studios, and Central Recording; Grade "B" for less critical listening, such as Announce and Talks studios and certain offices, and finally Grade "C" for general office use. Most of the loudspeakers in Broadcasting House are of Japanese manufacture and were supplied under the contract. For Grade "A", a duo-cone type is employed, having a 12" woofer and a 2" tweeter with cross-over frequency at 1,500 c.p.s. This is capable of a maximum power of 20 watts. For Grade "B", a 12" speaker with cone type tweeter is used. Maximum power capability 15 watts. The Grade "C" is an 8" speaker capable of 5 watts maximum power. Loudspeaker cabinets were designed by the N.Z.B.C. to suit the loudspeakers and were manufactured locally. In some instances, such as Announce and Talks rooms, the loudspeaker compartments are built into the studio wall acoustic treatment.

Microphones are supported in control rooms, Announce and Talks Studios, on a ceiling mounted, telescopic boom, positioned by means of a ball and socket joint. These booms were designed and manufacted by the N.Z.B.C. They are capable of supporting the heaviest type of microphone at an angle of 45° from vertical. This type of suspension solves the problem of obstruction to the desk top, noise transmission through the microphone stand and the problem of trailing cables. The cable is led up inside the stand column and across the top of the false ceiling and then down the wall in conduit let into the acoustic treatment to the floor wiring ducts. From here it is taken to the control desk termination blocks.

A radio "earth' separate from that of the building electrical services was provided for the equipment. This took the form of an "earth" grid of approximately 800 square feet in area constructed from bare, second-hand copper, tramway trolley wire buried below the grass plot on the Bowen Street frontage of the building. All joints on this earth grid were brazed and an insulated 19/·044 cable connects from the "grid" to the earth bus provided in the Master Control Room M.D.F. compartment. All cable shielding and the earth cables run from all the operational rooms throughout Broadcasting House "tie back" on to this earth bus.

The N.Z.B.C. decided to provide new technical facilities throughout Broadcasting House and so apart from the main equipment tender the N.Z.B.C. purchased additional items which included, microphones and microphone stands, outside broadcast equipment, test instruments, office auditioning facilities, artificial reverberation equipment and machine tools for the mechanical workshop. Much of the equipment previously in use on the Wellington stations was becoming "dated" and costly to maintain. Microphones now in use at Broadcasting House cover, dynamic, ribbon and condenser types of British, American, German and Japanese manufacture.

Performance of equipment

In general, a distribution level of + 8 dbm has been maintained for the internal distribution of programme. Long distant programme circuits are fed at a level of 0 dbm.

The overall frequency response of the equipment met the requirement of ± 2 dB of the level at 1 Kc/s from 30 c/s to 15 Kc/s and ± 1 dB of the level at 1 Kc/s from 60 c/s to 10 Kc/s.

Overall signal to noise ratio taken with a preamplifier input level of — 60 dBm and measured from a studio sub-control room via its equipment and routed through a Suite control room then measured at the output of the Master Control Room equipment gave a figure better than 55 dB.

Harmonic distortion introduced by the equipment does not exceed 1% over the range of 30 c/s to 15 Kc/s.

Adjacent channel interference (cross-talk) is better than 70 dB down over the frequency range 30 c/s to 10 Kc/s.

CONCLUSION

In the facilities now provided in Broadcasting House, the N.Z.B.C. is satisfied that the equipment is up-to-date, well constructed and has shown a good test performance. It has been claimed by the manufacturers as being a "World's First" for so large

—Please turn to page 40

A MAJOR BREAK-THROUGH IN SOUND PURITY

THE V-15 STEREO DYNETIC CARTRIDGE

A radically new, highly refined stereo phonograph cartridge designed especially for high fidelity purists who constantly seek perfection and are willing to pay for it, has been introduced by Shure Bros. Inc.

It is called the V-15 Stereo Dynetic.

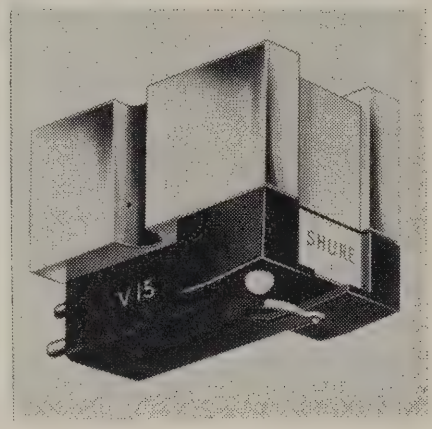
In reaching their objective with the V-15, Shure has combined the characteristics of a new stylus with ultra-critical manufacturing and quality control techniques.

Bi-Radial Elliptical Stylus

Providing the basic foundation of the V-15 is its Bi-Radial elliptical stylus. In both shape and performance it is a major departure from the conical styli which have been standard for many years.

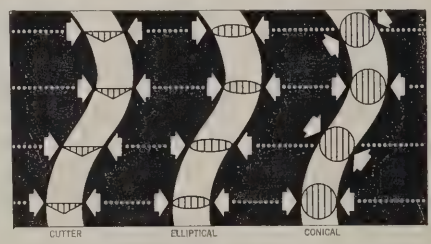
The primary design objective of the new stylus is to duplicate as much as possible the wedge-shaped styli used to cut records and thereby reduce distortion produced when a playback stylus does not track a record groove with the same motions made by a cutting stylus.

Unlike a standard conical stylus, which has a rounded spherical point, the tip of the Bi-Radial elliptical stylus is the shape of an elongated oval. It is set so that the larger frontal area of the oval is perpendicular to the record groove and its two tiny, well-rounded ends serve as contact points on each side of the record groove.



The radius of the broad frontal plane of the elliptical stylus is 22.5 microns (.0009 inch). But the radii of the actual contact ends on each side of the stylus are an incredibly fine five microns (.0002 inch), closely approximating the configuration of the cutting stylus that formed the intricate record grooves. Hence the edges of the Bi-Radial elliptical stylus track the grooves with much truer definition and less distortion than is possible with any conical stylus.

"Bottoming" (riding the bottom of the groove) is not a problem with the Bi-Radial stylus despite the micro-miniature dimensions of its record contact areas, because its broad frontal



plane of 22.5 microns (.0009 inch) keeps it riding at an optimum level within the record groove.

Tracing Distortion, "Pinch Effect" Also Minimised

Tracing distortion (which is quite pronounced with a spherical/conical stylus) is the result of constant change between the points of tangency or points of contact between the record grooves and the stylus.

But with the unique shape of the Bi-Radial elliptical stylus and its similarity to cutting styli, its points of tangency remain relatively constant, thus minimising tracing distortion.

The problem, known as the "pinch effect," is the result of the tendency of a spherical/conical stylus to rise and fall due to changes in the width of the record groove. A change in groove width occurs every time the flat, chisel-faced cutting stylus changes direction which can reach 20,000 cycles per second in some of the high overtones.

Since stereo styli and cartridges have both vertical and horizontal functions, unwanted up-and-down motion creates harmonic distortion. Again, to minimise this problem, the playback stylus should conform closely to the configuration of the cutting stylus, something the Bi-Radial elliptical stylus does with uniformity.

V-15 is a 15° Cartridge. Stylus Retracts for Record Protection

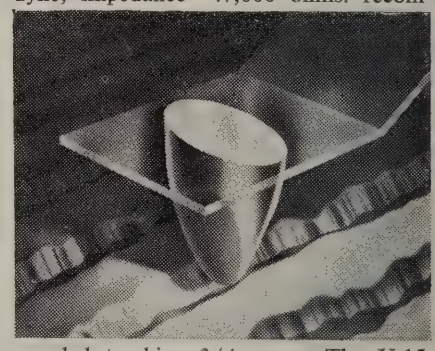
In still another effort to make the V-15 today's most advanced cartridge, it was designed so its stylus conforms to the effective record cutting angle of 15°. This feature was pioneered by Shure in its recently introduced medium-priced cartridge, the M44, with highly dramatic reductions in IM and harmonic distortion the result. The stylus is also designed to retract when excessive pressure is applied to the tone arm and thus protects records from developing annoying "clicks."

Ultra-Critical Manufacturing Techniques

To guarantee against the possibility of imperfectly formed elliptical stylus which would do more harm than good, Shure developed unprecedented manu facturing and inspection techniques to assure precise positioning, configuration and dimensions of the hard-to-work-with diamond tip.

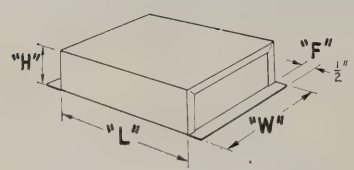
This kind of manufacturing discipline, in combination with the essential advantages of the Bi-Radial elliptical stylus, makes the V-15 truly a connoisseur's cartridge with a distortion level below the inherent noise level of test records and test instruments.

Other basic specifications of the V-15 are: frequency response—20 to 20,000 cps; output—6 mv; separation—over 25 db; compliance—25 x 10^{-6} cm. per dyne; impedance—47,000 ohms. recommended tracking 3/4-gram. The V-15, is packaged in a rich, solid walnut, re-usable box. It should, of course, only be used in an arm of the very finest quality, which will track accurately at 3/4 gram.



The New Zealand list price of the V-15 is £58/14/-, but duty and sales tax account for very nearly 45% of the total. The agents are Sonophone Distributors Ltd., Auckland.

BLANK CHASSIS



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HIGH POWER VARACTOR DIODES

continued from page 11

Efficiency

The efficiency of a varactor is a function of the cutoff frequency of the device which, in turn, is dependent on the diode quality factor (Q), defined as

$$Q = 1/2\pi fCRs \qquad (7)$$

From this, it is seen that Q is a function of both Rs and C. The ability to obtain a high Q device is directly related to the ability to make Rs extremely low. The cutoff frequency is arbitrarily defined as that frequency at which Q= 1, or where $\frac{1}{2}\pi fC = Rs$. Accordingly, cutoff frequency is given as

$$fc = \tfrac{1}{2}\pi CRs \qquad (8)$$

Since both Rs and C are voltage dependent, it is obvious that fc, too, will vary with applied voltage. As reverse voltage increases, fc will also increase. This is important in a comparative evaluation of devices since, in order to obtain a valid comparison, the fc for the devices must be obtained at the same voltage.

Now, for varactors with step junctions, the maximum obtainable efficiency may be approximated from the expressions: (1)

For input frequencies of 0.01 fc or less,

$$E = 1 - K\,(f_1/fc) \qquad (9)$$

For input frequencies of 0.2 fc or higher,

$$E = B(fc^2/f_1^2) \qquad (10)$$

where fc = cutoff frequency at V_B
f_1 = input frequency
K and B = constants whose values depend on the desired order of the harmonic.

For doublers, K and B of Equations 9 and 10 are equal to 20 and .0039 respectively.

For triplers and quadruplers, K is equal to 35 and 62 respectively.

From these equations it is evident that the theoretical efficiency of varactors is quite high at input frequencies of 0.01 fc or less.

Power Handling Capability

The relationship between power handling capability (Pr) and other varactor characteristics is given by

$$Pr \propto C_0 V_B^2 \qquad (11)$$

where V_B = voltage breakdown of the junction
C_0 = junction capacity at zero bias.

The validity of this proportionality is evident from the fact that the input power is obviously proportional to the square of the input voltage swing, which is limited at one end by V_B and on the other by the permissible amount of forward conduction. If the voltage swing in the forward direction is very much smaller than V_B, it can be neglected, and the input power is approximately proportional to V_B^2.

For large power handling capability it is desirable to make V_B as large as possible (assuming that the signal source can provide the necessary voltage swing from V_B to approximately zero). This requires that the resistivity of the material near the junction (at least on one side of the junction) be high. Yet, a high resistivity leads to a relatively high Rs which, in turn, lowers the Q of the diode and, consequently, the efficiency. Therefore, varactor diode design normally is a compromise between high power handling capability and high efficiency.

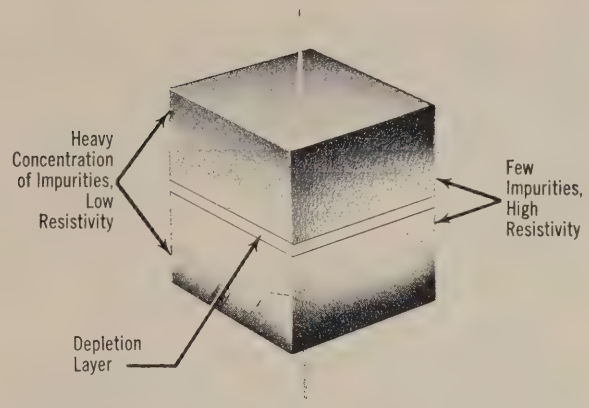

Figure 5 — Resistivity of 1N4386 is high near the junction and low near the lead contacts. When a reverse voltage is applied the depletion layer rapidly dissipates the high resistivity regions and thus, the average series resistance (R_s) is low.

New Varactor Design Improves Power Handling Capability

Until recently most varactors for harmonic generator applications have been designed with step junctions and their characteristics closely follow the above discussion. Some improvement in performance has been observed in varactors of the Motorola 1N4386 type whose impurity profile, Fig. 5, differs considerably from that of the customary step-junction device. These improvements include:

1) higher power handling capability at a given frequency,
2) greater linearity of power output with changes in power input.

The increase in power handling capability can be explained as follows:

To increase Pr, it is necessary to increase V_B which demands a higher resistivity material at least on one side of the junction. If one attempts to increase the resistivity of a step-junction device, the value of Rs is increased significantly and efficiency is reduced accordingly. But, by employing the impurity profile shown in Fig. 5, the resistivity near the junction can be made comparatively high without changing the average resistivity. Moreover, when reverse voltage is applied, the spread of the depletion layer into the high resistivity regions actually dissipates them, leaving only the extremely low resistivity portion of the material to contribute to Rs. And, since the time that the varactor is in the reverse-voltage condition is very large compared with the time in the forward-biased condition, the average total series resistance is substantially reduced despite the increase in resistivity at the junction and a resulting increase in V_B.

By this means, it is possible to almost double the power handling capability of varactors over

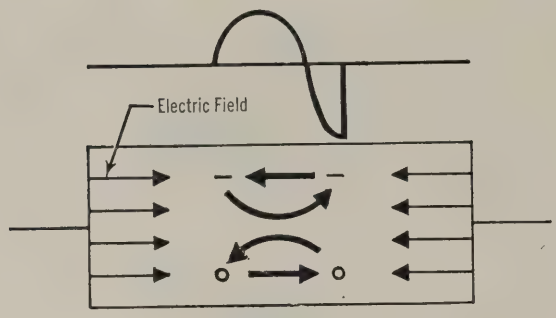

Figure 6 — When a forward voltage is applied, carriers are injected across the junction. However, before they can combine and result in a dc current flow, the applied voltage reverses and the carriers are returned to the point of origin in a bunch. This results in an abrupt cessation of reverse current and the waveform is rich in harmonics.

step-junction devices, without adversely affecting efficiency, at least as it is affected by Rs.

It might be argued that the impurity profile used in the 1N4386 type should result in lower efficiency because the capacity-voltage law (1 in Equation 1) is reduced to about a 1/5 power, thus reducing the degree of reactive nonlinearity. Indeed, this would result in a lower efficiency of harmonic generation if it were not compensated by the reduction of series resistance described above.

In addition there appears to be an added nonlinearity resulting directly from the parabolic graded impurity profile—the phenomenon of "step-recovery." Not only does step-recovery make up for the reduced junction-capacity non-linearity, but it leads to a linear power output advantage when driven slightly into the forward bias region at the positive peak of the signal swing.

Step-recovery is a result of charge storage—a familiar phenomenon in the application of semiconductor devices. When a p-n junction is forward biased, charged carriers from one region are injected into the other to form minority carriers in that area. If permitted to wander around in the area long enough, these minority carriers will combine with majority carriers and produce a current flow. The interval between injection and recombination is related to the minority carrier "lifetime" of the material. In the interval between the time of injection and recombination these minority carriers are effectively stored charges contributing to junction capacitance.

If the period of the applied forward voltage is less than the carrier lifetime, as is usually the case, most of the injected carriers can be brought back to the point of origin before recombination. Step-recovery comes about when the injected minority carriers are returned to the point of origin in a compact bunch. Such a movement of carriers constitutes a current waveform as shown in Fig. 6. Because of the sudden cessation of reverse current when all of the carriers are returned to their original regions, the waveform is rich in harmonics which can be utilised as an added nonlinearity to enhance multiplier action.

The impurity profile of Fig. 7 enhances step-recovery because the electric fields set up by the steep impurity gradient a short distance away from the depletion region keep the minority carriers close to the depletion layer, rather than permitting them to wander to random depths into the opposite regions. Thus, when the voltage is reversed, they return to their point of origin in a compact bunch.

The step-recovery phenomenon, which is not as pronounced in step junctions because of the constant impurity level in such devices, provides an additional nonlinearity to the 1N4386 which contributes to harmonic generation.

Step-recovery results also in a device with more linear power characteristics because the percentage of harmonic current generation is not a function of signal level. It is only a function of the waveform and the abruptness of the decline of reverse current. And if self-biasing is employed, the shape of the current wave remains constant over a considerable power input range. This leads to a more constant efficiency of harmonic generation as a function of signal level than obtainable with devices dependent on junction-capacitance variations alone. This is an important feature when using varactors in amplitude modulated circuits.

Harmonic Generator Circuits

Development of a varactor multiplier circuit is illustrated in Fig. 8. The basic premise, as shown

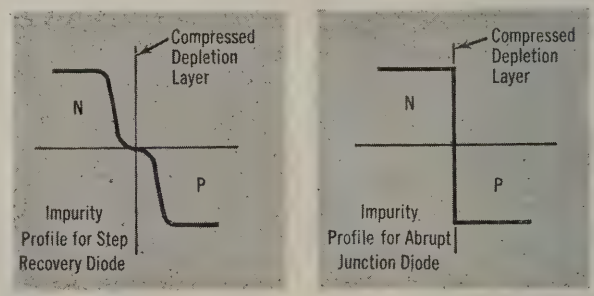

Figure 7 — Comparison of the impurity profiles for a step recovery and step junction diodes.

in (a) is the conversion of a signal from a signal source to a harmonic current through the load (R_L) by means of a varactor. The necessary considerations entail 1) provisions for the necessary current paths and associated filters, 2) proper matching of source to load, and 3) development of suitable bias voltage for the varactor.

The first step in the design is the addition of suitable current paths, as shown in (b). If the output is to be the second harmonic, filter F_1 is tuned to the fundamental frequency, and F_2 is tuned to the 2nd harmonic. In designing the tuned circuits, the capacitance of the varactor must be taken into account. Since this varies over the applied signal cycle, the "average" varactor capacitance should be used. This can be approximated by the capacitance value at one-third of the voltage breakdown rating of the varactor (assuming a signal voltage swing from about V_B to some small positive value). Since this average capacitance varies with signal power, some circuit detuning occurs if input power is changed appreciably. The detuning effect is less pronounced with devices of the 1N4386 struc-

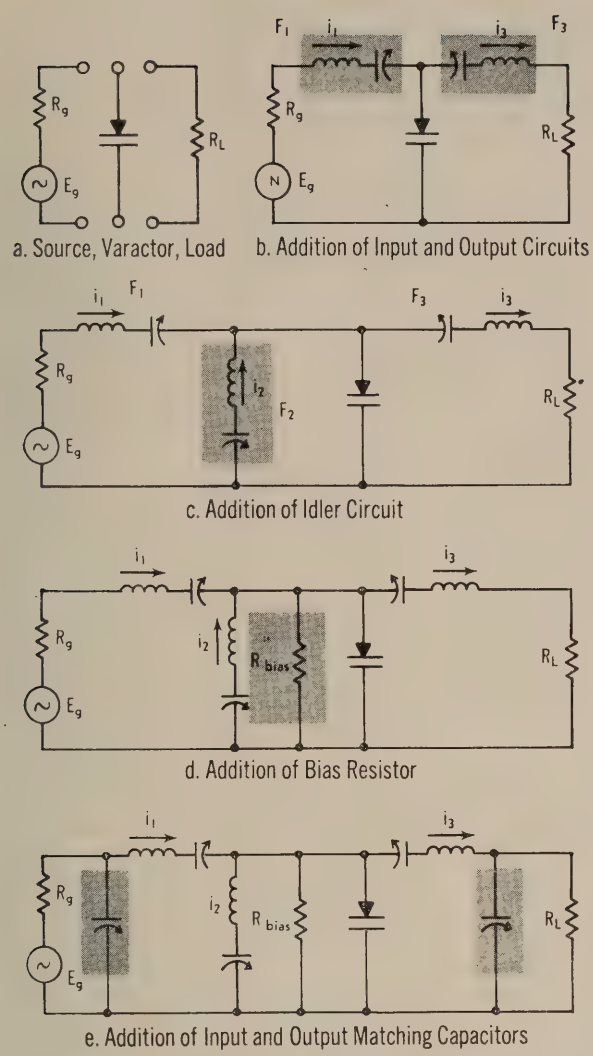
a. Source, Varactor, Load
b. Addition of Input and Output Circuits
c. Addition of Idler Circuit
d. Addition of Bias Resistor
e. Addition of Input and Output Matching Capacitors

Figure 8 — Development of a harmonic generator circuit.

ture than with step-junction devices.

If the desired load current is at the third or fourth harmonic, the configuration in (c) may be used. Here, F_1 is again tuned to the fundamental and F_2 is an idler tuned to the 2nd harmonic. This permits fundamental and 2nd harmonic current flow to mix in the varactor to provide a voltage component of $F_1 F_2$, $F_1 + F_2$ and $2F_2$ across the varactor. (Even if F_2 were omitted, there would be components of higher order harmonics, such as F_3 and F_4 across the varactor, but, as mentioned previously, it is normally more efficient to employ a suitable addition or multiple of the fundamental and second harmonic). Filter F_3 is then tuned to the desired third or fourth harmonic so that only the desired current will flow through the load.

Bias voltage for the varactor is obtained by shunting the varactor with a high value (around 100 KΩ) bias resistor, as in (d). Bias current is provided when the varactor is driven slightly into conduction at the peaks of the applied signal.

Proper matching between source and load can be accomplished by adding matching capacitors as shown in (e). Tapped input and output coils could accomplish the same purpose.

Obviously, the simple circuit developed in Fig. 8 can be improved upon from a performance standpoint. Higher-frequency, distributed-element circuits could be fabricated based on a circuit equivalent to Fig. 8. More complex filters, such as double-tuned circuits, may be employed for greater bandwidth and better rejection of spurious signals. In practical applications, the final circuit almost always will be more complex.

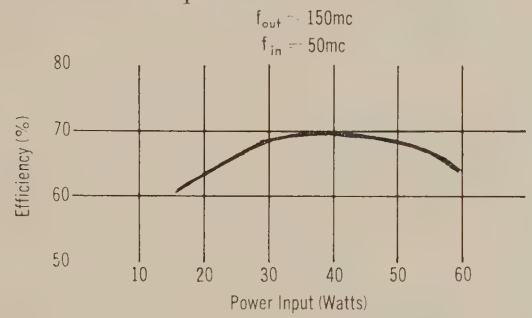

Figure 9 — Typical efficiency vs power input curve for the 1N4386 in a tripler circuit.

Characteristics of 1N4386

The 1N4386 varactor is designed to handle efficiently more than 50 watts of input power with output frequencies up to 300 mc. Typical efficiency of the device as a function of power input at 50 mc (tripler operation) is shown in Fig. 9.

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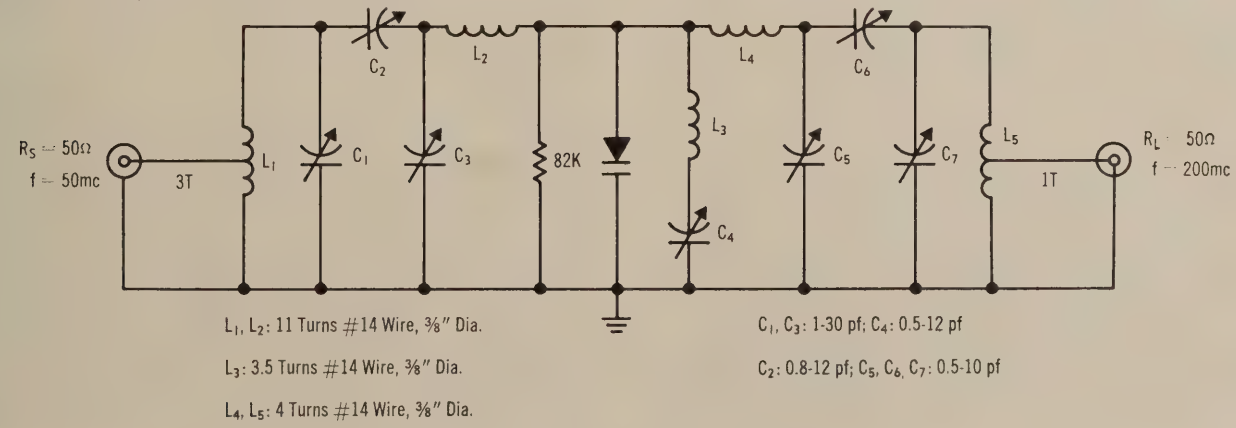

Figure 10 — 50-200 mc Varactor quadrupler

RADIO WAVE PROPAGATION

continued from page 17

It is, therefore, very important that the relative merits of several heights of aerial should be carefully investigated for all promising sites. This becomes increasingly so as the frequency is raised.

From the viewpoint of radio propagation, the chosen site should enable:

(a) The desired area to be served as effectively as possible with an economic mast height and value of radiated power, and without causing an unacceptable level of co-channel interference within the service area of any existing station operating on the same channel.

(b) The studios to be linked economically, by means of audio or video cable or by micro-wave link, to the transmitting station.

(c) The signal from one station to be received by direct "off the air" pick-up at one or more other stations required to radiate the same programme or, failing direct pick-up, to enable the programme to be conveyed via the minimum number of micro-wave relay stations.

Unfortunately, considerations unrelated to radio propagation often have to influence the choice of site. Amongst these are:

(i) accessibility and cost of building an approach road,

(ii) the cost of bringing power and water supplies to the site,

(iii) availability by purchase or renting,

(iv) suitability of the subsoil for supporting a mast of adequate height and the transmitter building,

(v) proximity to airfields and the danger of the mast to flying aircraft,

(vi) planning permission, especially if the site is at or near a recognised beauty spot,

(vii) proximity to a town — remote and isolated sites accentuate the difficulties of recruiting and retaining staff.

A site, in spite of excellent propagation characteristics, may well be eliminated by one or more of the above considerations but, usually, weighing up the advantages with the disadvantages is likely to lead to a compromise solution. This article, however, is concerned solely with the propagation aspects and in subsequent discussion these unrelated considerations will be ignored, except to point out that valuable planning time is likely to be saved if all relevant aspects can be investigated more or less simultaneously in order to recognise as early as possible any one factor which may decisively eliminate a site.

In the event of there being more than one promising site, their relative merits must first be assessed and compared. It is generally permissible to base this comparison solely on those towns for which a satisfactory service is considered essential since, at this early stage, to derive the optimum station characteristics and then to estimate the service area in detail would be time consuming and unjustifiable.

For each town, a sufficient number of ground profiles must be drawn from each site to enable a reliable prediction of average field strength to be made. Initially this would be for some arbitrary but convenient value of e.r.p, e.g. 1 kW or 50 kW. A brief study of the group of profiles from each site will enable an impression to be gained of the economic height of the mid-point of the aerial and, in cases where an excessively high mast would obviously be essential, the particular site can probably be eliminated without further investigation.

For each remaining site, the relationship between radiated power and field strength should be predicted for each town using perhaps one or two values of aerial height on either side of the value judged initially to be the economic height. From these relationships, it is an easy matter to calculate the value of e.r.p. required to provide any desired average field strength in each town.

Unless these values of e.r.p. have to be amended in order to prevent co-channel interference, there now emerges, for each aerial height at each site, an indication of the ideal shape for the azimuthal polar diagram of the aerial and the maximum value of e.r.p. required. Against the background of the relevant technical, economic and commercial considerations concerning available aerials, masts and transmitters, it becomes possible to visualise, in practical form, the equipment which would be needed for each site.

At the same time, consideration should be given to the vertical polar diagram of the aerial since, in a high gain aerial necessary for large service areas, the main lobe may be as little as 2 or 3° between 3 dB points. This narrow beam sometimes causes problems in coverage areas where the angle of depression, as seen from the aerial, to individual towns ranges over a wider angle, particularly when the station is located close to centres of population. Besides the need for effective filling in of the nulls of the polar diagram between the minor lobes, it may be necessary to give the main lobe a carefully chosen downward tilt.

Considerations of co-channel interference may, however, necessitate a reduction in the required radiated power in order to prevent excessive interference within the service area of another station or an increase to enable the wanted signal to override the unwanted signal by an adequate margin. It is at this stage in the planning that interference levels should be estimated, since the results may influence the choice of site or may show that a restriction in the desired service area will have to be accepted.

If radio links are required between studios and transmitter or between one transmitter and another, the profile of each path should be drawn and examined as soon as the choice of transmitting sites has been narrowed. The studio link, if too long for a cable, would be by micro-wave as would be the interstation link if "off the air" pick-up is ruled out by the nature of the path profile or by the enforced use of adjacent broadcast channels.

The planning of micro-wave links is outside the scope of this article, but two important requirements should, however, be mentioned. It is practically essential that the path between the aerial at each

end of the link should be optical, and it is unwise to attempt a one-hop link exceeding 55-65 km in length. In order to reduce costs, it is preferable for the transmitting station to be located, where possible, so as to enable these requirements to be met.

With so many and, often, conflicting factors to consider and weigh up, the final choice of the best all-round site can be difficult to make, but, in view of possible serious repercussions of a bad choice, time spent on careful and detailed planning is always fully justified.

Once a site has been selected, and the mast height, practical aerial polar diagram, transmitter output power and feeder loss have been settled, the service area can then be estimated.

Multipath reflections, particularly from buildings and hillsides, are inevitable and, if of sufficient time delay, can cause objectionable "ghosting" of the picture on a television screen or distortion in an f.m. sound service. In the majority of cases, careful siting and orientation of a high gain and, therefore, directive receiving aerial will provide adequate discrimination against offending reflections. It is not uncommon, however, to find that in badly screened receiving sites the best signal is obtained from a reflected wave.

In certain special conditions, reflections from the sea can result in a deterioration of reception in a seaside town. This may happen if a high hill severely screens the town from the transmitter but allows the sea to be strongly illuminated. In a particular combination of amplitude, spacing, direction of motion and speed of travel of the waves of the sea, a coherent reflection, or "back-scatter," will be returned to the town which will interfere with the relatively weak direct signal.

In Great Britain, this effect has been observed in the Plymouth area([7]) from the B.B.C. transmitter at North Hessary Tor (lower v.h.f. band) and at Ventnor from the I.T.A. transmitter a Chillerton Down (upper v.h.f. band).

Conclusion

What has been said so far has been concerned almost exclusively with the transmitting side of a broadcast service and so, by way of conclusion, a brief reference will be made to the receiving side.

Even "the best laid schemes o' mice and men gang after a-gley" ([8]) and, no matter how carefully the transmitting stations have been planned, the expected coverage will not be achieved to the full unless the receiving installations are of a reasonable standard of efficiency. This is particularly important not only in the fringe areas but also in the numerous localities, or even individual receiving sites, which lie closer to the transmitter but are screened by buildings or local hills.

Assuming that the receivers are of modern design, suitable for the transmission standards in use, and correctly aligned, the difference between good and indifferent reception may well depend on the receiving aerial— its precise siting and orientation, its gain (relative to a dipole) and back-to-front protection ratio.

The primary function of the aerial is to provide a voltage at the input of the receiver which is sufficient to give an acceptable signal/noise ratio at the output. A simple dipole may be adequate or a multi-element array may be necessary to provide additional gain. In areas which are free from interference, gain may be needed merely to boost the wanted signal but, where interference is present, gain in the "wanted" direction may be less important than the need for a deep null in the direction of an interfering signal. The back-to-front protection ratio, therefore, is often a more important property of a receiving aerial than gain.

Indoor aerials often prove adequate in the lower v.h.f. and, to a lesser extent, in the upper v.h.f. band at sites which are optical, or nearly so, from the transmitting aerial. In the u.h.f. band, however, the use of indoor aerials is likely to be limited to within areas of high field strength relatively close to the transmitter.

The precise siting and orientation of an aerial become increasingly important the higher the frequency, partly in order to avoid a null due to the local interference pattern of the wanted signal and partly to discriminate against unwanted signals. The increasing number of tall blocks of flats makes it desirable to install a communal aerial on the roof rather than individual aerials at lower levels.

Experience has repeatedly shown that, once a service has become established, any subsequent change in the height of the transmitting aerial or in the pilar diagram, in order to extend the coverage, invariably has the immediate effect of bringing forth complaints of a deterioration in reception which gives the impression that nothing but harm has resulted from the change. The fact is that, in a minority of cases, a change in aerial height will, for example, alter the interference pattern of the direct and reflected waves, thus making it necessary to readjust the receiving aerials. An extreme example of this is where a service is opened from a temporary installation pending the completion of the final one.

Although all generally turns out well in the end, listeners or viewers may have to incur additional expense and, as a result, a certain amount of goodwill may be lost. Careful thought should, therefore, be given to the wisdom of starting a broadcast service from a temporary station.

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BOOK REVIEW

"**Fundamentals of Acoustics,**" by Lawrence E. Kingsler and Austin R. Frey, published by John Wiley and Sons Inc., New York and London. In this book, the authors endeavour to present, in as simple and concise a form as possible, the fundamental principles underlying the generation, transmission and reception of acoustic waves. A second purpose—they say,—is to apply these principles to a number of important fields in applied acoustics. In both instances, the authors have definitely succeeded. Whilst allegedly written for graduate and student reference, this book has filled a place as a reference text at engineering level as well, particularly now that it has been expanded to cover such topics as ultrasonic transducers, and architectural acoustics.

Whilst much of the text in the first half of the book is theoretical, there is still a considerable amount of information available from these chapters. To anyone working with audio, or acoustic engineering, the chapters on loudspeakers, microphones, speech, hearing and noise, are recommended reading. In particular, the section on speech, hearing and noise consolidates an enormous amount of information giving the basic requirements in a concise and effective manner. The text is enhanced with numerous diagrams and graphs.

The book concludes with a useful appendix giving such details as elastic constants and velocity of sound in solids, liquids, etc., and a glossary of symbols with page references for further investigation.

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N.Z.B.C. REPORT

Continued from page 33

a transistorised installation and the N.Z.B.C. cannot dispute this claim. Its general performance over a lengthy period is yet to be proven, but we have every confidence that it will stand the test well and that we should get many years of satisfactory service from this equipment. In the design, every effort has been made by the N.Z.B.C. to provide as economically as possible, all the facilities required for efficient operation. At the same time, with an eye to the future, provision has been made, where possible, for future expansion without the necessity of major modifications.

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17899	0·05	,,	,,	—
17902	0·1	,,	,,	—
17900	0·05	500	1500	300
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18707	0·01	750	2250	300
17896	0·02	,,	,,	300
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Choke:—C45. Use 400v P.I.V. Diodes.

R106 T.V. Power Transformer for Philips T.V. Kitsets

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230:106v @ 420mA D.C.
:12.6v C.T. @ 5A (2 windings 6.30v @ 5A each).
:6.3v @ .3A Picture tube winding.
Choke:—C45. Use 400v P.I.V. Diodes.

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:12.6v C.T. @ 5A (2 only 6.3v winding @ 5A).
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Choke:—C50. Use 400v P.I.V. Diodes.

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